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U. S. DEPARTMENT OF AGRICULTURE.

FARMERS' BULLETIN No. 76.

TOMATO GROWING.

BY

EDWARD B. VOORHEES, M. A.,
Director of the New Jersey Agricultural Experiment Stations and Professor of Agriculture, Rutgers College, New Brunswick, N. J.

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LETTER OF TRANSMITTAL.

UNITED STATES DEPARTMENT OF AGRICULTURE,
OFFICE OF EXPERIMENT STATIONS,
Washington, D. C., May 19, 1898.

SIR: I have the honor to transmit herewith an article on tomato growing, by Edward B. Voorhees, M. A., director of the New Jersey Agricultural Experiment Stations and professor of agriculture in Rutgers College, including notes on the fungous diseases of tomatoes, by Byron D. Halsted, D. Sc., botanist and horticulturist in the same institutions. This article includes the results of investigations and observations made by the New Jersey stations under the supervision of the author, as well as of those made at other experiment stations and elsewhere. The publication of this article as a Farmers' Bulletin is respectfully recommended.

Respectfully,

A. C. TRUE,
Director.

Hon. JAMES WILSON,
Secretary of Agriculture.

CONTENTS.

	Page.
Introduction	7
For the early market	8
Selection of varieties	8
Growing the plants	9
Selection and preparation of the soil	11
Setting the plants	11
Manures and fertilizers	12
Cultivation of the crop	15
Yield per acre	16
Gross and net receipts	16
Medium-early and late crops	17
Soil and manures	17
Tomatoes for canneries	18
Selection of the variety	18
Growing the plants	19
Selection and preparation of the soil	20
Fertilizing and cultivation of the soil	20
Setting and cultivating the plants	23
Cost, yield, and value of the crop	23
Tomatoes in the greenhouse	24
Varieties	24
The house and its management	24
Soils and fertilizers	24
Growing the plants	25
Training the plants	25
Pollination	26
Yields	26
Markets and prices	26
Insect pests and remedies	26
Fungous enemies of the tomato	27

TOMATO GROWING.

INTRODUCTION.

The tomato is adapted to a wide variety of uses in the household. It is easily grown as a general crop, bears shipping well, and can be provided throughout a long season. For these reasons, among others, it has come to be one of our most important vegetable crops. The method of culture varies with the object or purpose of the crop. The latter is usually classified as follows: (1) For early market, (2) for the medium and late market, and (3) for the cannery. To these should be added the greenhouse crop, which is beginning to assume considerable importance in some localities. The tomato is most important as an early market crop, probably exceeding in value any other one crop, particularly in the Middle and Southern Coast States and in the market-garden regions near all large cities. In the past the States of largest production have been New Jersey and Maryland, while in recent years the crop has become a prominent one in the Southern Coast States—Florida, Georgia, the Carolinas, and Virginia, the first of which begins to supply the markets in February. Thus a continuous supply is provided from the field from that date until late in the autumn. Statistics as to the total areas grown are not available, although for New Jersey the data gathered indicate that at least 2,500 acres are devoted to the early market crop, yielding on the average 300 five-eighth bushel baskets, each weighing 40 pounds, or a total crop of 6 tons per acre. The gross price per basket ranged from 25 cents to $2.

The area devoted to the medium and late market crop in the Middle States, though not so large, is very considerable, and the prices received are relatively lower, although it is regarded as a profitable crop.

The tomato is grown more largely for canning than any other vegetable used for this purpose. The total annual pack of the entire country now averages nearly 5,500,000 cases of 24 cans each, and the area required to supply the canneries is estimated to exceed 300,000 acres. The bulk of the crop for this purpose is, however, grown in a few States, Maryland leading, with over 1,000,000 cases, and New Jersey following, with from 500,000 to 700,000 cases. The four States, Maryland, New Jersey, Indiana, and California, produce about three-quarters of the entire pack, and New Jersey and Maryland produce nearly one-half. The other States of considerable production are, in their order, Delaware, Missouri, Ohio, Virginia, and Iowa. It is thus observed that this crop is adapted to a wide area and is an industry of very considerable importance in a few of the States.

The discussion of the culture of this crop will follow the classification already suggested, except where methods practically coincide in the different classes.

FOR THE EARLY MARKET.

While the great development of the greenhouse industry enables the consumer to secure tomatoes throughout the entire year, those grown in the open field reach the Northern markets from Florida about the first of February and are followed by supplies from States farther north until about the middle or latter part of June, when they begin to come from Maryland, Delaware, New Jersey, and New York (Long Island), localities within the immediate vicinity of the large cities—New York, Philadelphia, and Boston. Inasmuch as the bulk of the early tomatoes, so called, are from these latter States, the consideration of methods will apply mainly to the crop as grown in those States, though the suggestions as to the general methods of culture apply quite as well to other localities.

SELECTION OF VARIETIES.

The first point of importance in the successful growing of the tomato crop is the selection of varieties, and while a number are recommended by seedsmen as the "best," no one variety fulfills the idea of "best" for all localities. This is mainly owing to differences in the climate, season, and character of the soil, as well as the demands of the different markets. Hence the right selection is a matter which rests largely with the individual grower. He must determine for himself which is the best for his conditions. The best early varieties, owing to the comparatively short time during which attention has been given to the matter of their development, doubtless belong to the same strain. The following-named varieties all possess one or more valuable characteristics, and in many cases but little difference is observed in them either as to quality or earliness. From this list varieties most suitable for the different localities may be selected. The order in which they are named has no particular significance:

List of more important varieties of tomatoes.

Livingston Beauty.
Dwarf Champion.
Maule Imperial.
Extra Early Richmond.
Improved Trophy.
Mikado.
Early Ruby.
New Stone.
Early Jersey.
Matchless.
Perfection.
Trucker Favorite.
Atlantic Prize.
Fordhook.
Acme.
Table Queen.
Stone.

The chief difficulty in the matter of varieties is that the earlier sorts as a rule do not possess the best market qualities—that is, solidity of flesh and smoothness. They are too frequently irregular in outline and possess large seed cavities. The peculiar demands of the market, too, should be considered, for, while in all markets the quality as above defined measures, as a rule, the price received, certain markets demand characteristics, such as color and shape, to a greater degree than others. Certain consumers are very strenuous in the matter of color. The purplish-tinted varieties, which are claimed to be sweeter, bring a much higher price in some markets than those of a bright red color, while in other markets the bright reds lead and the former are not so eagerly sought. Hence, as already stated, the question of variety is to be determined largely by the grower, and the best growers as a rule aim to grow and improve that variety which does best under his conditions—that is, he does not depend altogether upon seedsmen, but selects and saves seed of the particular variety which fulfills his aim as to earliness, vigor, habit of growth, size, color, and form. He selects his seed from the first ripening fruit upon strong and vigorous plants, and though this method is expensive, it is believed by those who practice it that the gain in earliness, yield, and quality of the fruit the ensuing season more than balances the extra cost. One or two days' gain in the earliness of finer-quality tomatoes frequently makes a difference in the market price of from 50 cents to $1 per basket.

GROWING THE PLANTS.

In the growing of early tomatoes the proper kind of plant exerts a great influence upon the product, and too much stress can not be laid on the necessity of giving close attention to the little matters of detail which to an ordinary observer are apparently of no consequence. Success with this crop requires that not a single point should be neglected in the growing of the plants. The aim is to anticipate nature, to get ahead of her in all points, and hence all of the operations necessary to this end must be executed with intelligence and promptness and with the greatest care. All conditions should be made favorable for rapid germination of the seed and the quick, healthful growth of the plant from the time the seed is planted until the crop is harvested.

The tomato is a plant that revels in high temperature, and is not only retarded in growth, but is injured by a low temperature during its early growth. From 60° to 80° are the limits of temperature range; hence the first desideratum is that the plants for early fruiting shall be grown either in a hothouse or in the hotbed, where the temperature can be controlled. The house is preferred by many, though both methods are very successfully used.

The seed should be planted any time from the middle to the latter part of February in the Middle States, and in the other States earlier or later, according to the locality. If grown in the house, they should be planted in a fertile soil and one that will not bake or crust. An abundance of vegetable matter is desirable. Lines are marked out in the bed 6 inches apart, and not over one-half inch in depth, and the seed distributed in the rows, averaging, as nearly as possible, four to the inch.

If planted thicker, the seedlings should be thinned to this distance after they are up, and in no case should they be left to stand any thicker if good, strong, healthy, stout, and stubby plants are desired. With good soil and with proper attention the seedlings should appear in from eight to ten days. When the seedlings are well up, the treatment should be such as to prevent long and spindling growth, which is frequently caused by an oversupply of water and too high temperature. Careless watering may also result in damping off and in a too soft and succulent growth. It is better for the plants to have too little rather than too much water. If the seedlings have been properly cared for, they should be ready for transplanting in about a month or six weeks.

Many persons now use for this purpose the cheap plant boxes, 6 by 6 by 5 inches, in the house, rather than to transfer to a cold frame. In putting the plants in the boxes one man fills each box about half full of a compost made up preferably of an even mixture of horse and cow manure, to which is added for each ton an equivalent of from 20 to 25 pounds of nitrogen in the form of dried blood, tankage, or cotton seed meal, and then passes the box to another man, who fills the remaining space with any good soil—that from the bench in the greenhouse answers the purpose—and the box is then placed upon the bench in the greenhouse. From this time on the plants should be well watered and the temperature kept at from 60° to 75° F. in the daytime and not lower than 50° at night, with proper ventilation as needed.

If these conditions are carefully complied with, the plants will be strong and healthy.

In growing the plants in a hotbed, fresh stable manure is put in to a depth of 18 inches. This is covered with 5 inches of good soil, and the seeds sown as described. When the plants have made four large leaves and are beginning to develop, which usually requires about a month or six weeks, they are ready for transplanting, though the work should be done only when the weather conditions are favorable, and by a careful person. It should not be done on cold or stormy days, nor by a person who does not understand the work.

In making the cold frames two important points should be observed: (1) They should have a pitch of about 6 inches, in order to carry off the water, and (2) the soil should be well manured, say a ton of stable manure to twenty 3-by-6-feet sashes. This length of bed is very desirable, as there are no corners and no crosspieces to obstruct the light. After the manure is in, care should be taken to make it perfectly smooth, so that the depth of soil (about 5 inches) may be uniform, as different depths of soil will cause a variable growth and a larger proportion of poorer plants, besides making the bed very uneven. The soil should be raked down level, the sash put on, and the bed allowed to remain at least two days to settle and become warm before the plants are introduced. When the plants are ready to be set, the bed should be stirred to destroy any weed seeds, and then marked off in checks 4 or, preferably, 5 inches each way.

After the plants are placed in the bed their subsequent development will depend very largely upon the care given to them. In a general way the main precautions to be observed are: Not to keep the plants too warm, and to give them air and water when necessary. Too little air and too much water have a tendency to make tender plants, although, on the other hand, if given too little water they are retarded in their growth and seem never to be able to recover from the check.

When the weather becomes warm, the sashes should be entirely removed on clear days, in order that the plants may be gradually hardened for setting in the open field. It is desirable to allow the beds to be entirely open all night a few times previous to setting. If proper attention is given to the plants during this critical period, they should be ready for the field from the 1st to the 10th of May. They should be from 12 to 15 inches in height, with strong, well-fibered stalks as thick as the finger, with a number of crown blossoms and numerous side branches.

SELECTION AND PREPARATION OF THE SOIL.

While the tomato is adapted to a wide variety of soils, it must be remembered that the aim here is early maturity; hence a too fertile soil, or one in which the fertility is widely distributed, and which is desirable where a general crop is grown, is to be avoided, since such soils tend to produce a too rapid and too large growth of vine, thus partially defeating the purpose in view, namely, a quick growth of plant and a rapid development of fruit. The active fertilizing matter should be concentrated within the immediate reach of the roots. A soil not naturally very poor, in which the added fertility may be provided, both as to place and time, as will best serve the purpose, is most desirable. A light, sandy loam, high and well drained, is perhaps the ideal for early tomatoes, provided the proper nourishment is given from artificial sources.

The previous treatment of the soil should be such as to free it from weeds and to leave it in a thoroughly friable condition. A crop of corn, potatoes, sweet potatoes, or melons is better to precede tomatoes than a hay crop. A clover or timothy sod, or a green crop, such as rye, may, however, precede, provided it is plowed either in fall or very early in spring in time to permit of a thorough mellowing by cultivation before the plants are set. After this preparation the usual practice is to open furrows 4½ feet each way, throwing the dirt both ways, and leaving a furrow at least 8 inches deep and 10 inches wide at the bottom.

SETTING THE PLANTS.

The setting in the field should not begin until the weather is settled. A warm, bright day should be selected, and the work pushed as rapidly as possible. If set on a cold, dark day, the beginning of growth will not only be greatly retarded. but the early settings are liable to be blasted. The plants should in all cases be thoroughly watered in order to obviate as far as possible any bad effect from immediate drought or hot weather. If the plants have been grown in boxes, the operation of planting may be carried on as follows:

For carting to the field, a low-wheeled wagon lengthened to 16 feet, on which a plank is placed which will carry about 225 plants, is very convenient. When in the field boys carry the boxes and set them by the hills; two men follow, take the boxes in hand and turn out the block of earth with the plant. If manure has been used in the hill, this is divided and the plant placed in it and surrounded by the manure. Another man follows with a hoe and draws the loose soil from both sides of the furrow around the plant, and presses it firmly with his feet.

Plants thus set rarely wilt or feel the effects of the setting, and start at once into new life and vigor of growth. If the conditions are favorable, new roots will be formed in forty-eight hours.

If the plants have been grown in cold frames, they are cut in blocks, say of from four to six plants, and lifted with a fork and set in the wagon, the same as in the bed. When the field is reached, each plant is cut out singly and set in the hill with all the soil adhering to the roots. The setting is done as in the former case.

MANURES AND FERTILIZERS.

The feeding of the tomato, as generally practiced, is accomplished in three ways, all of which are good—the cost of labor and manure usually determining the method used: (1) By means of farm manures; (2) by farm manures and commercial fertilizers, and (3) by commercial fertilizers alone. When manures only are used, they are usually spread broadcast upon the soil in the fall or winter, not later than February or March, and thoroughly worked in previous to putting out the plants, and at the time of setting a small shovelful of manure is placed in each hill. This method works well, though on soils reasonably rich the tendency is to cause too vigorous a growth of vine, and thus retard the maturity of the fruit. Where manures and fertilizers are used, the manures are usually applied in the hill, and the fertilizers are used both at the time of setting and again after the growth of the plants has well started. Where fertilizers only are used, they are applied around the plants in small quantities at the time of setting, and again in larger quantities after the plants have well started.

The impression is quite prevalent that the tomato does not require heavy manuring. Experiments that have been conducted at a number of experiment stations[1] show that the tomato is a plant that quickly and profitably responds to the use of manures or fertilizers, and that the maturity and yield are very largely influenced by the method of manuring and fertilizing. Experiments conducted by the New Jersey

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[1] New York State Sta. Buls. 21 and 32; Georgia Sta. Bul. 17; Maryland Sta. Rpt. 1891; Virginia Sta. Bul. 11; New Jersey Stas. Bul. 79, Special Bulletin O, Rpt. 1892, and Bulletin 136.

Station upon three farms, located in different parts of the State, and during four seasons, to test the effect on maturity and yield of nitrate of soda in different quantities and at different times, both with and without the mineral elements, phosphoric acid and potash, in comparison with barnyard manure, showed (1) that nitrate of soda was one of the best nitrogenous fertilizers for this crop, and that its use in small quantities (160 pounds) per acre in one application, or in large quantities (320 pounds) in two applications increased the yield materially, but not at the expense of maturity, and that this was equally true when used alone and when used in connection with phosphoric acid and potash; (2) that nitrate of soda, when used in large quantities (320 pounds in one application) in the presence of a sufficient excess of phosphoric acid and potash, did increase the yield, but at the expense of maturity, and (3) that when properly used nitrate of soda was a profitable fertilizer for the crop. This latter point is strikingly shown in the following tabulation of the value per acre of the increased yield:

Value per acre of the increased yield of tomatoes due to use of fertilizers.

Fertilizers per acre.	1889.	1890.	1891.	1892.	Average of four years.
Group 1, 160 pounds nitrate of soda	$59.80	$28.80	$79.60	$35.40	$50.90
Group 2, 160 pounds nitrate of soda, 320 pounds bone black superphosphate, and 160 pounds muriate of potash	55.40	12.80	60.20	40.80	42.30
Group 3, 320 pounds nitrate of soda	51.20	17.80	37.80	50.80	39.40
Group 4, 320 pounds nitrate of soda, 320 pounds bone black superphosphate, and 160 pounds muriate of potash	47.00	9.80	10.00	33.00	20.05
Minerals alone, 320 pounds bone black superphosphate and 160 pounds muriate of potash	32.40	2.80	61.20	34.20	32.65
Barnyard manure, 20 tons	11.80	21.40	16.40	40.00	23.40

The effect on total yield of the use of nitrate of soda alone and in combination with mineral elements, as compared with barnyard manure, is also shown in the accompanying tabulation, in which the yield of the different fertilizers is compared with the unfertilized land, which is represented by 100:

Comparative yields of tomatoes for four years, the yield on unfertilized plats being taken as 100.

Fertilizers used.	Comparative yield.				Average for four years.
	1889.	1890.	1891.	1892.	
Plat 1, no fertilizer	100	100	100	100	100
Plat 2, nitrate of soda alone, 160 pounds per acre	133	133	154	142	141
Plat 3, nitrate of soda alone, 160 pounds per acre	139	152	153	139	146
Plat 4, nitrate of soda alone, 320 pounds per acre	132	151	177	150	153
Plat 5, nitrate of soda alone, 320 pounds per acre	136	142	169	163	153
Plat 6, minerals containing phosphoric acid and potash only	105	121	120	131	119
Plat 7, nitrate of soda, 160 pounds per acre, and minerals as in plat 6.	131	126	160	159	144
Plat 8, nitrate of soda, 160 pounds per acre, and minerals as in plat 6.	154	138	161	140	148
Plat 9, nitrate of soda, 320 pounds per acre, and minerals as in plat 6.	145	149	161	149	151
Plat 10, nitrate of soda, 320 pounds per acre, and minerals as in plat 6.	158	147	159	147	153
Plat 11, barnyard manure, 20 tons per acre	107	120	113	153	123
Plat 12, no fertilizer	100	100	100	100	100

A study of these yields shows that nitrate of soda was superior to both barnyard manure and mineral fertilizers alone, and that nitrate of soda alone was, on the whole, but slightly less effective than the complete fertilizers.

These results have been confirmed both by the experiments of the stations referred to and also in actual practice on soils similar in character, namely, those which were well adapted for the early tomato—light, well-drained, sandy loams—which had been previously well manured for crops entering in the rotation. The results do not apply in the case of very poor soils, or upon heavy clays, which are not adapted to the early crop. The statement that it pays to fertilize early tomatoes and that nitrate of soda is one of the best nitrogenous fertilizers for the crop is true, though modified always by the condition of soil and the purpose of growth. A scheme of fertilizing for early tomatoes is here outlined, which, when the conditions are observed, will be likely to give as good returns if not better than any other.

For example, on soils which have been well supplied with the mineral elements, phosphoric acid and potash, by previous manuring or fertilizing, a fertilizer very rich in nitrogen (in the form of nitrate) and low percentages of phosphoric acid and potash, should be used. The fertilizer applied at the time of setting the plant should furnish nitrogen equivalent to from 80 to 100 pounds of nitrate of soda (13 to 16 pounds of nitrogen), and a second application of an equivalent amount should be made from three to four weeks later. A single application of the amounts here suggested, at the time of setting the plants, would, under good seasonal conditions, give quite as good results as a fractional application, although, if larger quantities are used, two applications would be better, since the nitrate is extremely soluble and if applied in large amounts at one time loss of nitrogen by leaching might occur in certain cases, resulting in a deficiency of food, and thus preventing the normal development of both plant and fruit.

On soils that possess only good mechanical condition, and are very poor in plant food, a heavier application of both nitrogen and the mineral elements will be required, in which case the following plan of fertilizing is recommended:

Previous to setting the plants, or at the time that they are set, apply 600 pounds per acre of a mixture of 400 pounds of acid phosphate and 200 pounds of muriate of potash, and thoroughly harrow or cultivate into the soil, and at the time of setting apply around the hill 100 to 150 pounds per acre of nitrate of soda.

Three to four weeks later, make another application of from 100 to 150 pounds per acre of nitrate of soda. Owing to the small bulk of the nitrate, it should be mixed with dry soil or sawdust in order to insure even distribution, the only precaution to observe is to prevent its immediate contact with the plant roots.

This method possesses two advantages, (1) the plant is provided with nitrogen in an immediately available form at the time when it is needed, namely, when it is set in the field, and thus no delay in growth is caused, and because of the presence of the mineral elements either in the soil or in the fertilizer applied no excessive growth of vine is encouraged by the use of the nitrate, as would be the case were the mineral elements absent; (2) the nitrate is applied around the plant within the immediate reach of its roots, and since it is all in an immediately available form, which may be used up rapidly, the tendency to late plant growth, a result of a continuous supply of nitrogen, is not encouraged, and a normal and rapid growth and development of fruit results.

It is not claimed that by this method of fertilizing maturity is hastened in the sense that the date of the first picking is earlier, but that a larger number of fruit is picked earlier. It was not shown in any of the experiments that the date of picking was earlier by virtue of the nitrate; in fact, the earliest tomatoes were picked upon land where the minerals only had been applied. The yield here, however, was not satisfactory, but where nitrate was applied the crop was so greatly increased that a larger proportion of early tomatoes was secured. It is obvious that inasmuch as the price of the fruit rapidly declines as the season advances, receipts will be materially increased by the increased crop of earlier fruits.

Where it is desirable to use yard manures with fertilizers, because of the abundance and cheapness of the former, they should be applied broadcast, and the nitrate applied at the time of setting the plants, as already described, rather than both in the hill together, as the tendency in the latter case would be to cause a loss of nitrogen from the nitrate, depending upon the amount of organic matter in the manures. That is, both experiments and experience have shown that manures will, under these circumstances, cause more or less of the nitrogen of the nitrate to escape as gas. Another precaution to observe in the use of yard manures for early tomatoes is, not to use too large quantities, as they are virtually nitrogenous manures, which, because of their character, feed the plant in proportion to their rate of decay, hence the presence of large quantities will encourage not only an undue growth of plant, but a late growth as well.

The mineral fertilizers, such as acid phosphate and muriate of potash, can be used with the yard manure with perfect safety, in fact with great advantage, because supplementing its lack of the mineral constituents.

CULTIVATION OF THE CROP.

Cultivation of the soil should begin the next day after setting the plants, in order to counteract the effects of the treading and packing of the soil due to the setting, and thus to aid in warming up the soil and to prevent a too rapid evaporation of water. The crop should be cultivated after every rain, and should no rain fall for a considerable time it should be cultivated every week until the vines fall, when the plants can take care of themselves. The chief object in cultivation here is to rid the land of weeds, to conserve moisture, and to keep the surface soil warm. Any more frequent cultivation for the sake of furnishing plant food is not desirable when the fertilizing has been carried out as suggested.

YIELD PER ACRE.

Plants handled and fertilized in the manner described should produce ripe fruit in from five to six weeks. In New Jersey the picking is usually completed early in August, though much, of course, depends upon the variety in this regard, and also upon the weather conditions at the time of the first setting of the fruit. If the weather is bad, then the main crop must be derived from the second setting, which will lengthen the period of picking. The yield per acre also varies widely, due both to variety and weather conditions. Some varieties may be regarded as shy bearers, while others are very prolific. In certain seasons the weather is favorable for the crop, warm and dry at the right time; in others, unfavorable, cold, wet, and backward.

A good average yield on land well adapted to the crop, and when the conditions are favorable, is about 250 bushels, though the yield may range from 100 to 500 bushels per acre. Tomatoes are not, however, sold by the bushel, but by the basket or crate, the basket holding, as a rule, five-eighths of a bushel, and the crate three-fourths of a bushel.

GROSS AND NET RECEIPTS.

The gross receipts from good growers average about $200 per acre, though the range, as heretofore indicated, will be from $100 to $500, the receipts per basket or per crate depending somewhat upon the season. In seasons of large production the price per package will be lower, and in the season of small production the price per package will be higher, making the gross receipts about the same, though the net receipts vary according to these circumstances, chiefly because of the larger amount of labor involved in the larger crop and the increased charges for freight rates and cartage.

The net receipts or profits in the growing of tomatoes, as will be observed from the preceding statement, will depend upon the care and judgment exercised in all of the various steps that have been mentioned, though too great stress can not be laid upon the necessity of extreme care in growing the plants. It is on this, other things being equal, that the profit hinges, for without a good plant a good crop can not be expected unless the other conditions are unusually favorable. In the handling and marketing of the crop much depends upon the care used in carting and packing. It does not pay to send poor stock to market, though, as already stated, the earlier varieties are not, as a rule, of as high quality as those produced later—the quality being determined by color, shape, and solidity. Tomatoes partially green, or those which are intermixed with rough specimens, and those containing a considerable proportion of smaller or overripe fruit do not bring the highest price in the market, and the tendency of such stock is to reduce the consumption and hence the price of the good product.

Estimates of expenses per acre by experienced growers in New Jersey are as follows:

Cost of growing tomatoes in New Jersey.

Cost of plants, at $15 per M	$32.00
Preparation of land, setting of plants, and cultivation	9.00
Manures and fertilizers[1]	27.50
Picking and carting to depot	20.00
Total	88.50

The rent of land, which would vary from $6 to $15 per acre, and the freight, cartage, and commission, which are variable factors, are not included in this estimate.

MEDIUM-EARLY AND LATE CROPS.

The medium-early and late crops of tomatoes may follow after peas, early radishes, spinach, and crops of that sort, and since they may be set in the field later, less expense is necessary in the growing of the plants, though for good, strong plants, the seed should be planted early in March in the States of largest production. The seed may be sown in a well-prepared bed, in rows 6 inches apart, the seeds averaging about four to the inch in the row. With good conditions and care, the plants should be well developed early in May, and they should then be transferred to a cold frame, prepared as for the early sorts. In transferring the plants as much root as possible should be saved. Owing to the advanced season, the danger of frost being past, the sashes may be taken off and the plants left to the natural climatic conditions, preparatory to setting in the field, which may take place early in June.

SOIL AND MANURES.

The soils best adapted for these crops, as for the very early, are well-drained, sandy loams, although, as the object of the growth is different, those richer in natural fertility are preferred.

While it is desirable, as in the case of the early tomatoes, to hasten growth, and to encourage continuous growth, the soil should be well prepared and quick-acting fertilizer applied, though the amount may be reduced at least one-half (preferably omitting the second application), particularly on good soils, as the conditions during the season of growth are favorable for the rapid changing of the organic nitrogen in the soil into active forms.

The setting of the plants and the methods of cultivation, already described, should be followed. The yield per acre for good soils, when the proper conditions are observed, should average about 300 bushels.

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[1] If fertilizers only are used, this item may be very much reduced.

The prices received for this crop are usually very much lower than for the early crop, though much depends upon the season and yield. When the early season is cold and wet the net value of a second early or late crop is often quite as great as that of the early crop, owing to the fact that the chief expenses—the cost of plants and of fertilizers—are reduced, the former from $15 to $5 per M, a saving of $20 per acre, and to a saving of at least $5 per acre in the fertilizers. Good growers expect about $100 per acre as the gross value of the crop.

TOMATOES FOR CANNERIES.

The tomato is now so largely grown as a regular field crop that it might seem as if but little could be said concerning the methods to be observed, although, as in the other cases, success requires definite knowledge and careful practice along the four lines already emphasized: (1) The selection of the variety; (2) the growing of the plants; (3) the selection and preparation of the soil; and (4) the fertilizing and cultivation of the land.

SELECTION OF THE VARIETY.

Owing to the fact that in canned tomatoes it is difficult for the average consumer to note any deficiencies in the appearance of the original fruit, many labor under the delusion that any variety will do for this purpose. This is a mistaken idea, as quality in canned goods is now an important factor, and it is quite as necessary that a good quality of product should be used as in growing for the early or general market, though from the field side it is natural that tonnage should be a primary consideration.

In the matter of varieties, as in the case of the early tomatoes, too much dependence should not be placed upon the name or upon the fact that a neighboring farmer secures good results from a given variety, since there are so many variations in the character of soils, even in the same locality, which exert an influence upon the size and quality of crop that the best variety is usually one that is, in part at least, developed by the individual grower. The main point is to select varieties that produce large, smooth, solid fruits, that ripen to the stem; those which possess size as their chief characteristic are frequently of poor quality, as they are likely to possess large seed cavities and to ripen unevenly. The Stone, Paragon, Ten Ton, Cumberland Red, and Livingston Perfection are all varieties that have been grown with advantage, though, as before stated, the variations due to the conditions cause a considerable change from the original variety. In fact, in many localities no definite variety name is known, neither is it known where the original plant came from, and thus it assumes a local name, as, for example, in New Jersey, the "Jersey Red" is probably grown more largely than any other, though it possesses very different characteristics in different localities, and is a development and improvement of some good variety introduced at an earlier period.

The conditions are such in some sections as to prevent the canners from making as much distinction between good and poor varieties as they would like to do. Largely owing to the liking of the growers for the large sorts, the coarser varieties, which give a heavy yield, have been substituted for those of finer texture, although there has been a gradual improvement in this regard. Canneries are in a measure obliged to receive all that come, unless they can control absolutely the land upon which they are grown. Frequently differences in the quality of the crops of different farmers will make a difference of from 25 to 40 cans on a ton of fruit, or from 6 to 10 per cent, a very considerable item. In good seasons and with good fruit, 400 cans may be regarded as the maximum amount to be derived from a ton, though late in the season, and with poor varieties, as already stated, the pack from a ton is very much less. The interests of both the grower and the canner are really identical in this regard. An improvement in the quality of the fruit will result in an improvement of the canned product and a consequent increase in the price of both the raw and manufactured products.

GROWING THE PLANTS.

The care and expense required in growing the plants for the crop for canneries are less than for the other crops, though the matter of plants is still a very important one. Here as in the other cases, good plants are a necessary factor for success. A good crop from poor plants can result only when all other conditions are extremely favorable.

In the growing of plants it is necessary to select a sheltered spot, either natural or artificial; the lee side of a high board fence, or building, is a desirable location, the main object being to protect the plant from the cold north and northwest winds.

The bed may be prepared either by working into a well-drained soil an abundance of well-rotted or composite manure, or by applying to it fertilizers of the right kind—that is, such as are soluble and available, and which at the same time will not retard germination or injure the young plantlet. As a rule, manures are preferable, as dressings of mineral fertilizers to provide the food required would naturally have a tendency to retard germination. After the bed is prepared it should be raked fine, all clods pulverized, and manure applied.

The seed should be planted shallow, as at this season of the year there is still a deficiency of warmth, and the nearer the surface the seed are planted the quicker they will germinate. As a rule, they should not be deeper than one-quarter of an inch, and the earth around the seed firmly packed, which can be well done by means of a board 1 foot wide and of a length equal to the width of the bed. This board will also do to stand on when sowing the seed. A light covering of salt hay, or straw, is also beneficial immediately after planting, in order to absorb the heat from the sun, and at the same time to keep the surface soil loose and prevent baking. The covering, however, should be removed before the seedlings break through the soil, otherwise the plants will be drawn and worthless. When the plants are an inch high the soil should be stirred. This stirring should be repeated frequently, particularly after each rain, as it induces more rapid growth, and more freely admits the warm air to the roots of the plant. Unless there is an abundance of rain, careful attention should also be given to watering, as the plants require a great abundance of water. If all these precautions are carefully observed, and the work properly carried out, good, strong, well-fibered plants should be ready for the field from the middle to the latter part of June—the time which they are usually set in New Jersey or Maryland. In other States the planting of the seed would naturally be a little earlier, thus making the setting in the field proportionately earlier.

SELECTION AND PREPARATION OF THE SOIL.

The tomato as a field crop is adapted to a wide variety of soils, though a medium clay loam is probably the best. In fact, any soil well adapted to potatoes will grow the tomato to good advantage. The previous treatment, however, has an influence on the best development of the crop, and a clover sod, or a soil upon which corn has been the preceding crop, is perhaps the best. In either case the land should be deeply cultivated, preferably in the fall or early spring, in order to improve its physical character and to destroy injurious insects,[1] which may be troublesome later. It is also desirable, where it is the practice to use manure, particularly if it is coarse, to spread it during the winter, in order that the soluble portions may become thoroughly distributed in the soil. As soon as the land is ready to work in the spring it should again be plowed shallow and then deeply cultivated, in order to thoroughly warm up the soil and to incorporate in it the coarser portions of the manure.

FERTILIZING AND CULTIVATION OF THE SOIL.

In manuring and fertilizing, the character of the crop and the season of its growth should be remembered. Hence recommendations that were made for the early crop do not apply in all cases, except, perhaps, on the poorer classes of soils. In the first place, the plants are not put in the soil until summer, when the conditions are most favorable for the rapid change of organic forms of nitrogen into nitrates, and thus if the soil has been manured, or is naturally rich in vegetable matter, the additional application of nitrogen in immediately available forms is not so important. In the second place, the object of the growth is not early maturity, but the largest yield of mature fruit. Hence it is more desirable to grow a larger plant than in the case of the early tomatoes. The fertilizing should be, therefore, such as to furnish an abundance of all the elements of plant food, and, inasmuch as the tomato belongs to the potash-consuming class of plants, the fertilizers used should be particularly rich in this element. It is not to be understood, however, that it is not necessary to apply nitrogen, for frequently soils are used that are either not naturally well adapted to the plant or have not been previously well supplied with vegetable matter containing nitrogen. On such soils additional nitrogen is very important, and nitrate of soda is one of the best forms to use, as it is absorbed fully by the roots, thus encouraging an early and vigorous growth of plant and a normal development of fruit. Slow-acting organic forms of nitrogen, on the other hand, frequently begin to feed the plant and cause its rapid growth when the energies should be concentrated in the growth and maturity of the fruit.

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[1] New Jersey Stas. Bul. 85.

Fertilizers that have proven excellent are those which contain a relatively smaller amount of nitrogen than is required for early tomatoes and large amounts of phosphoric acid and potash.

A study of the composition of both the fruit and vine of the tomato will serve to guide us in this respect, though the amounts and proportions of food removed by any crop are not an absolute guide, inasmuch as the soil may furnish more of one constituent than another, and because the plant may have the power of acquiring certain of its constituents more readily than others. In studying the amount of fertilizer to use, it is desirable to add more than will be contained in the increased crop, for two reasons: First, because it is impossible so to distribute the fertilizer as to enable the plant roots to come in contact with every portion of it, and second, because there is danger of loss of nitrogen by leaching, particularly during a wet season. The fertilizing constituents of the fruit and vines of tomatoes are as follows:

Fertilizing constituents in one ton of the fruit and vines of tomatoes.

	Nitrogen.	Phosphoric acid.	Potash.
	Pounds.	*Pounds.*	*Pounds.*
In fruit	3.20	1.00	5.40
Vines (green)	6.40	1.40	10.00

From this data it is calculated that in 10 tons of tomatoes, with the accompanying vines, which would probably reach 4 tons, there would be contained 57 pounds of nitrogen, 16 pounds of phosphoric acid, and 94 pounds of potash. On a good soil, therefore, which would, without manure, produce five to six tons, there should be added a sufficient excess of the constituents to provide for a maximun production, and the materials should be relatively richer in nitrogen and potash than in phosphoric acid. A mixture of nitrate of soda, 400 pounds; bone tankage, 700 pounds; acid phosphate, 400 pounds; muriate of potash, 500 pounds, would contain, approximately, 95 pounds of nitrogen, 144 pounds of phosphoric acid (48 pounds of which would be soluble and available), and 250 pounds of potash in each ton. An application of 500 pounds of this mixture would furnish half as much nitrogen as is contained in 10 tons of crop, nearly as much immediately available phosphoric acid and two-thirds as much potash. Hence a dressing containing the amounts, kinds, and proportions of plant food here indicated would be regarded as very desirable, since one-half of the nitrogen is in the form of nitrate, which would contribute to the immediate growth of the plant. The amount of soluble and available phosphoric acid is sufficient to satisfy the needs of the crop throughout its entire growth, and such an abundance of potash is present as to insure the maturity of both plant and fruit. Formulas of this character have been used with good success, though the large proportion of salts sometimes makes mixtures of this sort too moist to handle well, in which case a part of the potash or even the nitrate, may be applied separately with advantage. On poorer soils the artificial supply of plant food should be proportionately greater, or sufficient to provide for the entire needs of a fair-sized crop, since, as a rule, the relative power of the plant to acquire food is somewhat less on poor soils than on good soils, or, stated in another way, the results from the use of fertilizers are proportionately better upon soils in good condition than upon those not well cared for. A good formula for use on these soils may consist of nitrate of soda, 500 pounds; bone tankage, 500 pounds; acid phosphate, 400 pounds, and muriate of potash, 600 pounds.

One ton of this mixture would furnish approximately 105 pounds of nitrogen, 120 pounds of phosphoric acid, and 300 pounds of potash. The application of 1,000 pounds would, therefore, furnish the food in sufficient abundance and in good proportions to meet the demands of a fair crop. The advantage of using so large a proportion of nitrogen in the form of nitrate is that in this form it is immediately available, and induces the immediate and rapid growth of the plant, and prevents a too late growth by furnishing a minimum of organic nitrogen, which would become available late in the season. The cost of the fertilizer suggested in these cases, though apparently rather large, should not exceed $15 per acre, and is no more than would be required for fertilizers to insure a maximum crop of corn, or other field crop, on the soils described. Besides, it must be remembered that the quality of the crop would also be greatly improved. The necessity for so expensive a dressing could be materially lessened by reducing the need for nitrogen, and this could be accomplished by sowing crimson clover with, or after, the previous crop of, say, early corn or potatoes; in fact, if weather conditions are favorable, crimson clover may be seeded in the tomato fields in August after cultivation has ceased, or at the last cultivation, and a crop of clover grown which will provide nitrogen for the next year's crop. This method is now practiced with advantage by many growers. The cost of manuring or fertilizing tomatoes on soils in good condition, and which have been well managed for previous crops in the rotation, should not exceed $8 per acre.

SETTING AND CULTIVATING THE PLANTS.

The plants should be set from 4 to 4½ feet apart each way and cultivation should begin immediately. The first cultivation should be deep, in order to conserve the moisture, and each subsequent cultivation shallower, in order not to destroy the roots, which will fill the soil as soon as the plants reach maturity. The crop in good seasons should begin to ripen in August, and picking will continue from that time until the last of September.

COST, YIELD, AND VALUE OF THE CROP.

The cost per acre is of course much smaller than in the case of early tomatoes (see p. 17), the reduction in cost of plants being especially marked. The several items may be classified as follows:

Cost of growing an acre of tomatoes for canning.

Plants	$2
Manures and fertilizers	8
Preparation of land, setting plants, and cultivation	8
Picking and carting	10
Total	28

The yield, as in the case of the early tomatoes, varies widely, ranging from 5 to as high as 20 tons per acre, even 30 tons per acre having been reported in exceptional cases, although the average for a series of years on average land will probably be under 8 tons. Where all conditions are carefully observed, 20-ton yields are frequently obtained, and at the prices received at the cannery, ranging from $5 to $7.50 per ton, according to the locality, the crop is a fairly good one and the net profits quite as high as for other field crops.

The agreements made between the growers and canners differ somewhat, though the main object on the part of the canner is to secure sufficient tonnage to maintain the factory during the ripening season. It would seem that the fairest form of contract would call for the product of a certain number of acres rather than the delivery of a certain number of tons. It is impossible for the farmer to anticipate the season, and therefore he can not safely contract to deliver a definite number of tons. The following form of contract, which is quite generally used in New Jersey, is good and protects both the producer and the canner:

Form of contract between tomato grower and canner.

This is to certify that we ———, have bought of——— ———, the product of——— acres of——— for the season of ——— at ——— per ton, delivered at our cannery———. Stock to be in first-class merchantable condition. To be planted about ———.

Other provisions are frequently inserted to cover the date of the beginning of the delivery, as well as to protect the cannery in case of fire, accident, or other contingency.

The cooperation of farmers in the ownership and management of a cannery is practiced in a number of places, though it is not general.

TOMATOES IN THE GREENHOUSE.

The tomato is an important forcing-house vegetable, and may be made a profitable supplemental crop by those who are equipped with houses for growing plants for the outdoor early market crop. They can utilize their house for a winter crop of fruit before it becomes necessary for growing the plants for the field. It is very profitable when the conditions of growth are understood and carefully observed.

VARIETIES.

Few of the large number of varieties seem to be adapted for forcing. Those that have given the best results thus far are Lorillard, Chemin Market, Optimist, Ithaca, and Long Keeper. Of these, the Lorillard seems to fulfill the requirements as fully as any other sort grown in New Jersey. It is a good though not a prolific bearer, but the fruit is large, smooth, solid, and uniform in size. The Chemin Market is a rich-colored attractive tomato, but is uneven in outline and lacks solidity. Differences that are observed in the varieties in the more Northern States, with a minimum of sunshine, would perhaps not be so marked in winter climates having a larger proportion of sunshine.

THE HOUSE AND ITS MANAGEMENT.

The chief characteristic in a house is to have it light and tight, and high enough to allow the training of the plants to a height of at least 5 feet above the soil in the benches. Detailed information as to the character of houses and methods of growth and management are given in standard works on this subject.[1] The general plan of growing on benches is preferable; these should contain from 7 to 8 inches of soil, and lie immediately over the source of heat. In beds of this character the plants may be placed in rows 24 inches apart, and 18 inches apart in the row. The darker the house and the less the sunlight, the wider apart should the plants be set.

The proper temperature is from 60° to 65° F. for night, and about 75° F. for the day, at which temperature the house should be ventilated, though on bright days the temperature will run higher and will do no harm if it reaches 100° F. The atmosphere in the house should be kept in a well-moistened condition until the fruit begins to set, then the moisture should be reduced, as it hinders the setting of the fruit. Great care should be exercised in watering, especially on sunny days.

SOILS AND FERTILIZERS.

In growing forcing-house tomatoes, the character of the soil is apparently of less importance than the kind of manures and fertilizers and their method of use. It is our experience, as well as of others, that tomatoes may be grown in almost any kind of soil, even coal ashes, provided an abundance of available food is supplied.[1] Where manure is convenient and cheap, a rich garden loam, to which at least one-fifth of rich stable manure has been added, is most excellent, though even this should be supplemented with liquid manure, or fertilizer, nearly every week after the plants begin to grow. In the absence of a supply of yard manure, a reasonably fertile, loamy soil may be used for filling the beds, in which may be mixed, for each 100 square feet of surface, one-half pound of nitrate of soda, 1 pound of acid phosphate, and one-half pound of muriate of potash. This application will supply the needs of the plants for food until fruit begins to develop, after which they should be fertilized at least once each week with one-quarter of a pound of nitrate of soda for every 100 square feet of surface area, and with the mineral fertilizers at the rate of 1 pound of acid phosphate and one-half pound of muriate of potash every two weeks. These may be applied in solution, or evenly distributed over the surface of the soil, and worked in before watering. In our experience, there is but little danger of overfeeding—the strongest and most vigorous plants have produced the largest yields and the best quality of fruit.

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[1] The Forcing Book, L. H. Bailey. The Macmillan Company, 1897. Greenhouse Management, L. R. Taft. Orange Judd Company, 1898.

GROWING THE PLANTS.

The method recommended for growing the plants for the early market field crop apply fully in the case of those grown for forcing. The time required from sowing the seed until the plants are fit for transplanting in the beds ranges from two to two and one-half months. Hence if it is desired to have fruit by the middle of December, or the beginning of January, it is necessary to sow the seed early in August; these will then be ready to transplant in the house by the middle of October, and first fruiting will begin by Christmas time. The plants will continue to bear for longer or shorter periods, depending largely upon the method of training and feeding, though usually profitable picking will continue for from two to two and one-half months. Hence in order to secure a second crop in time to obtain fair prices, seed should again be planted in November, to begin fruiting in April. A person who makes a business of growing plants for early field crops could secure at least one house crop before the latter part of February, when it is necessary to plant his seed.

TRAINING THE PLANTS.

The plants should have sufficient water applied in such a manner as to thoroughly soak the soil—it should not be applied so as to puddle the surface and leave the lower layers dry. Experience thus far teaches that the best results are obtained by plants trained to a single stem, which are supported by stout strings attached to the rafters or other support above, and to which the individual plants are fastened by soft cord. Great care should therefore be exercised in pinching off the side shoots as they appear, and allowing only the blossom shoots to remain.

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[1] New York Cornell Sta. Buls. 32 and 45; Connecticut State Sta. Rpts. 1895 and 1896; Massachusetts Hatch Sta. Buls. 10 and 15; Ohio Sta. Bul. 43; New Jersey Stas. Bul. 141.

POLLINATION.

Experiments have shown that for the production of large even fruits, the tomato flowers must receive an abundance of pollen. Since pollen is discharged much less freely on damp cloudy days than at other times, it is desirable to pollinate artificially during a considerable part of the winter and early spring. Pollination is best done in the brightest part of the day when the atmosphere is comparatively dry. A very satisfactory way of distributing the pollen is to tap the blossom lightly with a small stick and thus jar the pollen out into a spoon, watch glass, or other convenient receptacle held below the flower, the pistil being depressed into the accumulated pollen at the same time. Pollinating may also be done by transferring the pollen from flower to flower with a camel's hair brush.

YIELDS.

When conditions are favorable, the average yield should be about 2 pounds for each 2 square feet of surface soil. The crop grown during the short winter days will always be slightly less than that grown when the days are lengthening.

MARKETS AND PRICES.

Care should be used in handling and putting up the fruit for market; it should not be bruised, and should preferably be placed in boxes holding from 4 to 10 pounds, each fruit wrapped in tissue paper and all carefully packed. The prices received will range from 10 to 50 cents per pound. The higher price is usually received in February and March, though in the past good prices have been received even after the Southern fruit comes in the market in considerable quantities, because of the superior quality of the greenhouse product.

With the prices obtained in the past the gross receipts for a season, December to May, from a house 20 by 100 feet, will range from $400 to $600, depending on the skill used in the management.[1]

INSECT PESTS AND REMEDIES.

An insect pest of the tomato, which frequently does great damage to the early-market crop, is the tomato worm; it is also known as the "corn worm" in the North, and the "boll worm" in the South.[2] This worm bores into the ripening tomoto and is thus difficult to deal with directly. The caterpillar that matures in corn in September or early October goes under ground and changes to a pupa, passing the winter in this condition. If the ground remains undisturbed, the moth appears in early spring and lays its eggs upon such plants as it can find, and early tomato plants are one of its favorites. The caterpillars bore at first into the stems, but always attack the fruit as soon as it is set and continue their ravages as long as fruit remains. Because they can not be treated except by picking and destroying fruit, the only practical method suggested is to fall plow all cornfields upon which tomatoes are to follow. The fall plowing breaks up the earthen cells in which the pupæ rest and results in almost every instance in causing their death. The pest is not so serious where corn has not been previously grown, in which case the necessity for fall plowing is not so great; still, inasmuch as the practice is a good one in any case, it is to be recommended where trouble from this pest occurs.

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[1] New Jersey Stas. Bul. 141.

[2] Economic Entomology, J. B. Smith, pp. 303–304 J. B. Lippincott Co., 1896.

Another pest, quite serious in some sections, is the Colorado potato beetle, which attacks the young plants as soon as they are set, and often does considerable damage. Here of course, before fruit has set, the usual remedy may be applied, namely, spraying with arsenites, at the rate of 1 pound in 75 to 100 gallons of water, in the same manner as for the destruction of the beetles when troublesome on potatoes.

A large green insect, called the "sphinx caterpillar," often does considerable injury. This insect is an external feeder, and the simplest remedy is to hand pick.

A small spotted mite is a pest which is frequently serious in the greenhouse; it feeds upon the under side of the leaves, causing the upper surface to appear speckled with white. The main remedy is the frequent syringing of the plants with fir-tree oil, used at the rate of one-half pint to 2 gallons of water.

The white scaly insect, which also does some injury, can be kept in check by fumigating with tobacco smoke.

The root gall, caused by a nematode worm, is also troublesome at times, in which case the soil should be removed from the house and only that used which has been thoroughly frozen.

FUNGOUS ENEMIES OF THE TOMATO.[1]

In the Northern United States the most destructive disease of the tomato is the leaf spot (*Septoria lycopersici*). It is easily recognized by the affected foliage becoming covered with minute brown specks and finally drying up and falling away, leaving the bare stems, which are also more or less spotted by the fungus. The disease gains a foothold in the plants while they are quite young, and therefore great care should be taken to have everything in connection with the propagating beds in the best sanitary condition.

Experiments have shown that where this disease is prevalent tomatoes should not be grown continuously upon the same soil, and all stems of plants should be burned at the close of the season.

A second troublesome disease of the tomato is due to a bacterium (*Bacillus solanacearum*) and is recognized by a sudden wilting of the foliage, followed by a yellow color that finally becomes brown. This disease of the tomato was first complained of in the South, but it is now found as far north as Washington, D. C., and may be expected as a troublesome pest by the truckers around Philadelphia and New York.

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[1] By Byron D. Halsted, D. Sc., botanist and horticulturist, New Jersey Agricultural Experiment Station, and professor of botany and horticulture, Rutgers College.

Other plants belonging to the same family with the tomato are affected with the same disease, as the potato, eggplant, petunias, and several common weeds, such as the Jamestown weed, black nightshade, and ground cherry. This germ disease is therefore not so easily controlled as those that infest only one kind of plant.

Much depends upon the condition of the foliage, and anything that opens up a passageway for the entrance of the germs renders inoculation more frequent.

E. F. Smith, of the Department of Agriculture, who has made a special study of this trouble, finds that it is transmitted from one plant to another by insects, the Colorado beetle and the flea beetles being among the ones most active in this distribution.

One of the chief preventive measures is, therefore, to protect the tomato plants from the attacks of insects by the use of insecticides. In addition to this, any plant that shows the characteristic wilt should be removed and burned, thus destroying centers of infection. It is well to practice rotation and not grow tomatoes upon or close to land where the crop suffered the previous year. The same rule holds true with potatoes and eggplants, and no weeds of the tomato family should be allowed to grow in or near the area devoted to the crop.

The fruit rot, sometimes called black mold (*Macrosporium tomato*), is a fungous disease, which usually begins at the blossom end of the fruit. It is frequently accompanied by other fungi that cooperate with it in causing the premature decay of the fruit.

Those varieties which have an imperfect blossom end are most susceptible, and care should be taken to grow the smooth-fruited sorts. For example, the rough-skinned soft fruits of the "peach" variety decay more extensively than the Dwarf Champion, with its smooth, hard fruit. The latter is an upright plant, and the fruit is less frequently upon the ground, and to this in some measure is due the comparative exemption from the fruit rot. This suggests the training of the vines to stakes or trellises, or using a straw mulch upon the soil to keep the fruit from touching the earth.

One of the most destructive of the fruit diseases is the anthracnose (*Colletotrichum phomoides*). This fungus attacks the fruit, usually producing small sunken places, which continue to enlarge until the tomato is ruined.

A common fungous disease of greenhouse tomatoes is the olive mold (*Cladosporium fulvum*). The infected leaves turn yellowish in patches, and upon the under side there is a felt-like olive-colored growth of mold, where the spores are produced in great numbers. The worst leaves should be removed and burned and spraying will help to keep the mold in check.

In conclusion, it may be said that fungous diseases of the tomato are found in all stages of the growth of the crop. Some begin in the propagating bed and flourish in the field upon leaf and stem. Others are confined to the fruit and destroy the tomatoes after they are picked, while some are usually present in the greenhouse.

They all produce spores or minute germs that are invisible and countless, and therefore all old vines should be destroyed and a wide rotation practiced by the trucker. It is to his advantage to set healthy plants, and be cautious in buying them or very careful in producing his own.

Many growers have found it profitable, after all other precautions are taken, to add spraying to the list of requirements in growing tomatoes. For this there is nothing superior to the Bordeaux mixture in any of its usual strengths.

FARMERS' BULLETINS.

The following is a list of the Farmers' Bulletins available for distribution, showing the number, title, and size in pages of each. Copies will be sent to any address on application to Senators, Representatives, and Delegates in Congress, or to the Secretary of Agriculture, Washington, D. C.:

16. Leguminous Plants. Pp. 24.
19. Important Insecticides. Pp. 32.
21. Barnyard Manure. Pp. 32.
22. The Feeding of Farm Animals. Pp. 32.
23. Foods: Nutritive Value and Cost. Pp. 32.
24. Hog Cholera and Swine Plague. Pp. 16.
25. Peanuts: Culture and Uses. Pp. 24.
26. Sweet Potatoes: Culture and Uses. Pp. 30.
27. Flax for Seed and Fiber. Pp. 16.
28. Weeds: And How to Kill Them. Pp. 32.
29. Souring and Other Changes in Milk. Pp. 23.
30. Grape Diseases on the Pacific Coast. Pp. 15.
31. Alfalfa, or Lucern. Pp. 24.
32. Silos and Silage. Pp. 32.
33. Peach Growing for Market. Pp. 24.
34. Meats: Composition and Cooking. Pp. 29.
35. Potato Culture. Pp. 24.
36. Cotton Seed and Its Products. Pp. 16.
37. Kafir Corn: Culture and Uses. Pp. 12.
38. Spraying for Fruit Diseases. Pp. 12.
39. Onion Culture. Pp. 31.
40. Farm Drainage. Pp. 24.
41. Fowls: Care and Feeding. Pp. 24.
42. Facts About Milk. Pp. 29.
43. Sewage Disposal on the Farm. Pp. 20.
44. Commercial Fertilizers. Pp. 24.
45. Insects Injurious to Stored Grain. Pp. 24.
46. Irrigation in Humid Climates. Pp. 27.
47. Insects Affecting the Cotton Plant. Pp. 32.
48. The Manuring of Cotton. Pp. 16.
49. Sheep Feeding. Pp. 24.
50. Sorghum as a Forage Crop. Pp. 20.
51. Standard Varieties of Chickens. Pp. 48.
52. The Sugar Beet. Pp. 48.
53. How to Grow Mushrooms. Pp. 20.
54. Some Common Birds. Pp. 40.
55. The Dairy Herd. Pp. 24.
56. Experiment Station Work—I. Pp. 31.
57. Butter Making on the Farm. Pp. 16.
58. The Soy Bean as a Forage Crop. Pp. 24.
59. Bee Keeping. Pp. 32.
60. Methods of Curing Tobacco. Pp. 16.
61. Asparagus Culture. Pp. 40.
62. Marketing Farm Produce. Pp. 28.
63. Care of Milk on the Farm. Pp. 40.
64. Ducks and Geese. Pp. 48.
65. Experiment Station Work—II. Pp. 32.
66. Meadows and Pastures. Pp. 28.
67. Forestry for Farmers. Pp. 48.
68. The Black Rot of the Cabbage. Pp. 22.
69. Experiment Station Work—III. Pp. 32.
70. Insect Enemies of the Grape. Pp. 23.
71. Essentials in Beef Production. Pp. 24.
72. Cattle Ranges of the Southwest. Pp. 32.
73. Experiment Station Work—IV. Pp. 32.
74. Milk as Food. Pp. 39.
75. The Grain Smuts. Pp. 20.
76. Tomato Growing. Pp. 30.
77. The Liming of Soils. Pp. 19.
78. Experiment Station Work—V. Pp. 32.
79. Experiment Station Work—VI. Pp. 28.
80. The Peach Twig-borer. Pp. 16.
81. Corn Culture in the South. Pp. 24.
82. The Culture of Tobacco. Pp. 24.
83. Tobacco Soils. Pp. 23.
84. Experiment Station Work—VII. Pp. 32.
85. Fish as Food. Pp. 30.
86. Thirty Poisonous Plants. Pp. 32.
87. Experiment Station Work—VIII. Pp. 32.
88. Alkali Lands. Pp. 23.
89. Cowpeas. Pp. 16.
90. The Manufacture of Sorghum Sirup. Pp. 32.
91. Potato Diseases and Their Treatment. Pp. 12.
92. Experiment Station Work—IX. Pp. 30.
93. Sugar as Food. Pp. 27.
94. The Vegetable Garden. Pp. 24.
95. Good Roads for Farmers. Pp. 47.
96. Raising Sheep for Mutton. Pp. 48.
97. Experiment Station Work—X. Pp. 32.
98. Suggestions to Southern Farmers. Pp. 48.
99. Three Insect Enemies of Shade Trees. Pp. 30.
100. Hog Raising in the South. Pp. 40.
101. Millets. Pp. 28.
102. Southern Forage Plants. Pp. 48.
103. Experiment Station Work—XI. Pp. 32.
104. Notes on Frost. Pp. 24.
105. Experiment Station Work—XII. Pp. 32.
106. Breeds of Dairy Cattle. Pp. 48.
107. Experiment Station Work—XIII. Pp. 32.
108. Saltbushes. Pp. 20.
109. Farmers' Reading Courses. Pp. 20.
110. Rice Culture in the United States. Pp. 28.
111. The Farmer's Interest in Good Seed. Pp. 24.
112. Bread and Bread Making. Pp. 39.
113. The Apple and How to Grow It. Pp. 32.
114. Experiment Station Work—XIV. Pp. 28.
115. Hop Culture in California. Pp. 27.
116. Irrigation in Fruit Growing. Pp. 48.
117. Sheep, Hogs, and Horses in the Northwest. Pp. 28.
118. Grape Growing in the South. Pp. 32.
119. Experiment Station Work—XV. Pp. 31.
120. The Principal Insects Affecting the Tobacco Plant. Pp. 32.
121. Beans, Peas, and Other Legumes as Food. Pp. 32.
122. Experiment Station Work—XVI. Pp. 32.
123. Red Clover Seed: Information for Purchasers. Pp. 11.
124. Experiment Station Work—XVII.
125. Protection of Food Products from Injurious Temperatures. Pp. 26.
126. Farm Buildings.
127. Important Insecticides.
128. Eggs and Their Uses as Food.
129. Sweet Potatoes.
130. The Mexican Cotton Boll Weevil.

243.--Revised.

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FARMERS' BULLETIN No. 77.

THE LIMING OF SOILS.

BY

H. J. WHEELER, Ph. D.,
Chemist of the Rhode Island Agricultural Experiment Station.

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LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Office of Experiment Stations,
Washington, D. C., January 25, 1899.

Sir: I have the honor to transmit herewith an article on the liming of soils, by H. J. Wheeler, Ph. D., chemist of the Rhode Island Agricultural Experiment Station, revised with very slight corrections. There has been in recent years a renewal of interest in problems relating to the use of lime for the improvement of soils. This is due in large measure to the work of the experiment stations. Among others, the investigations at the Rhode Island Station, under the supervision of the author of this article, have shown the great benefit which follows the use of lime on soils under proper conditions. The article is submitted with the recommendation that it be published as a Farmers' Bulletin.

Respectfully,

A. C. True,
Director.

Hon. James Wilson,
Secretary of Agriculture.

CONTENTS.

Page.
The use of lime for improving soils 3
Direct manurial action of lime 4
Chemical action of lime on soils 5
Physical effects of liming 5
The effect of lime on the action of microscopic organisms in the soil 6
Liming sometimes injurious 6
Plants benefited by liming 7
Plants injured by liming 8
Plants nearly indifferent to liming 8
Influence of lime upon some plant diseases 8
How often should liming be practiced 9
When to apply lime 9
How to apply lime 10
Forms of lime used for agricultural purposes 12
Summary 16

THE LIMING OF SOILS.

THE USE OF LIME FOR IMPROVING SOILS.

The recognition of the agricultural value of certain forms of lime is not new, and it appears probable from the writings of Pliny that liming was practiced by the Romans more than two thousand years ago. In England, Germany, France, and other European countries the application of lime in various forms has been and is still practiced extensively.

Dehérain states that certain regions of France have undergone a veritable agricultural transformation owing to the use of lime and marl. Müntz and Girard assert that more than one-fifth of the area of France is of granitic origin, and that when the soils are supplied with lime and phosphoric acid, which they lack, they undergo a complete transformation.

In certain sections of Germany carbonate of lime in the form of marl plays an important part in maintaining the fertility of the soil. According to Wicke, the yields in certain districts of Germany have been quadrupled by the employment of marl, and many plants whose cultivation was previously impossible can be grown at a profit after the soil has been limed.

That eminently practical as well as scientific agriculturist, Schultz, of Lupitz, has demonstrated the immense value of marl in developing the productiveness of the light soil of that section of Germany. By its use, in connection with abundant potash and phosphoric acid, he has caused leguminous crops to gather from the air large stores of nitrogen, thus making it possible to cultivate the light soils at a profit.

Haxton, in a prize essay "On light land farming," mentions a number of siliceous, sandy soils in various parts of England which are greatly benefited by liming, and in speaking of the granite formation in Scotland asserts that "the whole of the granite soils are deficient in lime, and the first step toward their improvement, after being drained, is to apply this substance in a hot or caustic state."

Ruffin is perhaps the most prominent of the earlier writers who called attention to the agricultural use of lime in the United States. As early as 1818, and later in 1821, articles on the subject were contributed by him to the American Farmer, and in 1832 appeared the first edition of his well-known work on "Calcareous manures." He cites many instances showing the benefit derived from calcium carbonate when applied in the form of marl to his own and other Virginia estates.

In certain parts of Pennsylvania and New York lime has long been considered one of the essentials in wheat production. The beneficial effect of liming has been demonstrated in other parts of the United States, especially in the eastern portion; but, as Roberts states, probably 99 per cent of the arable soil of the United States has never been limed. The work of some of the experiment stations, notably that of Rhode Island, has shown that soils which respond profitably to liming, either on account of their acid condition or of a deficiency of lime, are very widely distributed.

DIRECT MANURIAL ACTION OF LIME.

Authorities seem to agree that lime is necessary to the plant, and if it be wholly lacking in soils, even though an abundance of all the other essential elements is present, it can not develop normally. Just as a chain is useless with a missing link, so the plant can not grow if one of the essential elements of plant food is lacking. As already stated, lime has been found to be especially deficient in soils derived from granite. It is also often true of soils derived from mica-schist and sandstone. Fortunately, however, many soils are well provided with lime by nature and it is seldom or never necessary for those who cultivate them to resort to liming. It would be just as irrational to apply lime where it is not needed as to omit it where it is required, and hence arises the necessity of ascertaining the needs of particular soils in this respect.

The method usually resorted to for ascertaining the amount of lime in soils is to treat them with some strong mineral acid (usually hydrochloric) and determine the amount of lime which is thus dissolved. Some writers state that if only one-half of 1 per cent is thus shown to be present immediate resort to liming is desirable; others set the amount higher, and some seem to prefer to have present as much as 1 per cent. It is possible that a soil may contain considerable quantities of lime thus removable by acid and yet in actual practice show much benefit from liming. As a matter of fact, soils of limestone origin sometimes show benefit from liming. This seems to be due to the fact that a considerable amount of lime compounds, soluble in hydrochloric acid, may exist, and the soil be nevertheless so charged with inert organic matter or so acid that the profitable production of certain crops is an impossibility.

The fact that beets of all kinds make a ready response to liming on soils which are deficient in lime may be utilized as the basis for a practical and reliable method of testing the lime requirements of the soil. For this purpose lay out two plats of land, each about 12 by 30 feet, manure each of the plats with like amounts of a fertilizer containing potash, phosphoric acid, and nitrogen, and apply lime to one of the plats at the rate of from 1 to 2½ tons per acre (40 pounds per plat would be approximately 2½ tons per acre). A comparison of the growth and yields on the two plats will furnish a safe means of judging whether the soil will respond profitably to applications of lime.

CHEMICAL ACTION OF LIME ON SOILS.

Lime is said to take the place of potash in certain chemical compounds which exist in soils, thus liberating the potash and placing it at the disposal of plants. In this particular, gypsum (land plaster or calcium sulphate) is believed to act more energetically than carbonate of lime, air-slacked, or water-slacked lime.

When soluble phosphates are applied to soils deficient in lime and magnesia the phosphoric acid combines with the iron and alumina of the soil to form compounds which are not readily utilized by plants. If, however, the soil is fairly well supplied with lime and magnesia this transformation is retarded so that the plant is afforded an opportunity to utilize much of the phosphoric acid before it becomes unassimilable. If a soil containing a certain inert phosphate of iron is heavily limed, it is believed that this phosphate will be changed into a form which the plant can utilize. Lime may therefore not only help to maintain fresh applications of phosphoric acid for a long time in assimilable condition, but it may, if applied in sufficient quantity, help to unlock stores of phosphoric acid which plants would otherwise be unable to use.

Hilgard has abundantly demonstrated the great value of gypsum (land plaster) in renovating "alkali" soils in the arid portions of the United States. Wherever too much sodium carbonate (black alkali) is the cause of the unproductive condition of the soil the gypsum reacts with it, producing sodium sulphate and carbonate of lime, whereby the alkalinity may be sufficiently reduced to render possible the profitable production of crops.

In case protosulphate of iron and certain other poisonous compounds are present in soils, liming so changes them as to render them harmless to plants.

When the remains of plants undergo decay upon soils deficient in carbonates of lime and magnesia, acid or sour humus is liable to be produced, which is particularly noxious to most agricultural plants, though perhaps helpful to the growth of lupines and a few others. Such conditions are liable to occur even in upland and naturally well drained soils. Liming is in all such cases an effectual and probably the most economical remedy.

PHYSICAL EFFECTS OF LIMING.

Many clay soils when wet by rains are not porous enough to allow the water to pass through them with sufficient rapidity, in consequence of which they become water-logged and the air which is necessary for the healthful development of plant roots within the soil is excluded. In times of drought, also, such soils cake readily, thus becoming more difficult to till and less adapted physically to the growth of plants. Liming is an effective preventive or remedy for all of these unfavorable conditions. Upon certain loamy soils containing considerable clay liming often renders the surface more friable and less liable to form a crust upon drying.

The improvement of drainage brought about by liming is one of the most effective means of preventing surface washing. When heavy rains occur on limed soils the water sinks into the soil instead of rushing over the surface, carrying the fine soil particles with it and thus producing galls and washes.

Soils which are composed of siliceous sand are frequently benefited by being rendered more compact by liming. On such soils carbonate of lime is preferable to air or water slacked lime, owing to the caustic nature of the latter, and the best material to employ where it is obtainable is a clay marl containing a fair amount of carbonate of lime. The clay as well as the lime tends to materially improve the physical condition of the soil. It should also be the aim to increase the amount of organic matter in such soils by the use of muck and stable manures, or by the occasional plowing under of a green crop or of sward.

THE EFFECT OF LIME ON THE ACTION OF MICROSCOPIC ORGANISMS IN THE SOIL.

Many important changes are produced in the soil by organisms so small that they can only be observed by the aid of the most powerful microscopes. Some of the changes of this character in which lime plays an important part are the following:

(1) The change of ammonia and of nitrogen in organic matter, such as blood, meat, fish, tankage, plants, etc., into nitrates, the form in which it is chiefly assimilated by most cultivated plants. This is known as the process of nitrification and is promoted by the presence of lime in soils.

(2) The decomposition of organic matter in muck and other soils. In this process the production of carbonic acid is much accelerated by the use of lime. This carbonic acid in turn so acts upon the inert plant food of the soil as to make it more quickly available to plants. The indirect result, therefore, is to help the plant to draw more potash, phosphoric acid, etc., from the soil than would otherwise be possible.

(3) The utilization of atmospheric nitrogen by certain of the leguminous plants (notably the clovers), particularly upon sour soils, is facilitated by the application of lime.

LIMING SOMETIMES INJURIOUS.

Excessive amounts of lime, especially on light soils, may have an injurious action. This is particularly true of freshly slacked lime upon light sandy soils containing but small amounts of organic matter. It hastens unduly the decomposition of the organic matter, and thus renders the soil more open and less retentive of fertilizers and moisture than before. If freshly slacked lime must be used upon such soils it should be applied in small amounts and at not too frequent intervals.

As stated heretofore, clay marls are much better adapted than other forms of lime for the improvement of such soils. In lieu of such marl, wood ashes or lime which has been exposed to the action of the air for a long time, might be preferable to lime freshly prepared.

Before the advent of complete fertilizers it was a common adage that liming "makes rich fathers and poor sons." If lime is used alone it serves to liberate potash, nitrogen, and perhaps sometimes phosphoric acid, and the extra drain of increased crops on the soil naturally leaves it finally in a worse condition than at the outset. In other cases, the soil reverts after many years to its former state of unproductiveness without appreciable injury. Continued success from liming can only be obtained by the use of the other essential manurial fertilizing constituents in connection with the lime. Few, if any, cases are on record where soils originally in need of lime have failed to continue to give good results from liming when care was taken to maintain a supply of the other essential constituents and where lime was applied in moderate amounts.

There are impure forms of lime which, after burning, will harden like cement, and which on this account may have an injurious action upon the soil. If pulverized without burning, they are capable of yielding good results.

Dolomitic (magnesian) limestone contains widely varying percentages of magnesia and lime. Such stone if containing high percentages of magnesia may sometimes prove objectionable if used exclusively. When such material is applied to soils the lime is removed by crops and the drainage water more rapidly than the magnesia, and if the lime thus becomes practically exhausted the residual magnesia in the soil may have an injurious action. This can, however, be overcome by adding more lime. Rather than use such lime for long periods of years on the same land, it would be preferable to alternate frequently with lime containing little or no magnesia.

Some magnesia in lime is by no means objectionable, and may, on certain soils, prove positively beneficial.

PLANTS BENEFITED BY LIMING.

The following are some of the plants which, in experiments on acid soils at the Rhode Island Experiment Station, have shown marked benefit from the use of lime: Spinach, lettuce, beets (all kinds), gumbo (okra), salsify (vegetable oyster), celery, onion, parsnip, cauliflower, cucumber, eggplant, cantaloupe, asparagus, kohl-rabi, cabbage, dandelion, Swedish turnip, pepper, pea, peanut, martynia, tobacco, sorghum, alfalfa, clover, barley, wheat, oats, timothy, and Kentucky blue grass. Not only was the crop greater, but in many instances it was ready for market much earlier where the soil was limed. There was at least two weeks' difference in kohl-rabi in this respect. Tobacco not only made a much better growth when limed, but the ash was much lighter in color.

PLANTS INJURED BY LIMING.

A few plants have shown considerable injury from the use of lime; these are, serradella, watermelon, blue lupine, and common sorrel (*Rumex acetosella*). Only one season's results are on record with serradella, but the other plants have been tested for several seasons with the same result. Extensive European tests have also shown the lupine to be injured by liming. Though common sorrel is directly injured by liming, the chief effect of lime in ridding land from sorrel seems to be attributable to its favoring the growth of cultivated plants to such an extent that the sorrel is smothered by them.

PLANTS NEARLY INDIFFERENT TO LIMING.

Standing between the two groups of plants given above are a number which when they are supplied with all of the nitrogen they require in a readily assimilable form, such as nitrate of soda, show little or no benefit from liming. Among those are Indian corn, common millet, Hungarian, golden millet, rye, potatoes, carrots, Rhode Island bent (grass), and redtop (grass). On a very acid or sour soil even those plants would be benefited by lime by virtue of its helping to change the nitrogen into readily assimilable nitrates, provided sulphate of ammonia, blood, tankage, fish, cotton-seed meal, plant roots, etc., were present as sources of nitrogen.

The above tests, carried out at the Rhode Island Station, were made in the field upon a soil well supplied with superphosphate, muriate of potash, and nitrate of soda, and also in some of the later tests with magnesia.

INFLUENCE OF LIME UPON SOME PLANT DISEASES.

Potato scab.—It has been shown that carbonate of lime and such other forms of lime as are changed into the carbonate by decomposition within the soil all tend to favor the production of potato scab, provided the germs of the disease are already in the soil or are introduced into it on the seed tubers. This seems to be due to the fact that the lime makes the soil alkaline, or to some influence which the combined carbonic acid of the carbonate of lime exerts upon the development of the fungus.

In view of this unfavorable action of lime, caution should be observed in liming potato fields. If such fields are to receive the treatment, they should be limed, if possible, some time before potatoes are to be grown. The seed tubers employed should also be treated before planting with corrosive sublimate solution or some other effective fungicide.[1]

Club root.—Many writers seem to agree that liming is capable of lessening materially the injury to turnips, cabbages, etc., caused by the disease known as "finger-and-toe" and "club root." English writers assert that by resort to liming excellent crops of turnips have been produced where without it the crop was a failure owing to the attacks of the disease.

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[1] For method of treatment see U. S. Dept. Agr., Farmers' Bul. 56 (Experiment Station Work—I).

Other diseases.—The effect of lime in different forms has been tested, with not entirely conclusive results, on various other diseases, including cranberry and sweet potato diseases, and a root disease of alfalfa (*Rhizoctonia medicaginis*). Slacked lime was found to be effective in reducing soil rot of sweet potatoes, and quicklime in checking or preventing the root disease of alfalfa.

HOW OFTEN SHOULD LIMING BE PRACTICED?

The frequency with which liming should be practiced depends upon several conditions; for example, upon the character of the soil, the quantity of lime employed in each application, the number of years involved in a rotation, the plants to be grown and their order of succession. Formerly, in England, large quantities of lime were applied at somewhat rare intervals, but there and elsewhere at the present time the preferable practice seems to be to use small amounts and apply it more frequently. As a general rule it may be stated that from half a ton to one and a half tons of lime per acre applied every five to six years is sufficient. There may exist extreme soils requiring either more or less than these amounts. If soils which are quite acid and have not previously been limed are to be seeded, with the intention of allowing them to remain in grass for several years, as much as two or three tons of lime per acre may be advisable. Only very extreme cases would call for larger applications. If in a rotation covering a considerable number of years two crops especially benefited by lime are introduced at about equidistant intervals of time, it may be advisable to lime twice in the course of the rotation, each time just prior to their introduction. In renovating acid pastures and meadows it is usually preferable to apply a fair amount of lime upon the furrows when they are first plowed so that this may be thoroughly mixed with the soil by subsequent plowing and harrowing, and just prior to seeding to grass make another generous application. By such treatment, provided the other essential fertilizing ingredients are employed, a good stand of clover, Kentucky blue grass, timothy and other grasses may be obtained where in many instances they were formerly partial or total failures and where only redtop, Rhode Island bent, and grasses having similar soil adaptability could be grown. Where land is kept in grass for a number of consecutive years, top-dressing with lime may be advisable, particularly if ordinary commercial fertilizers are employed in lieu of stable manure.

WHEN TO APPLY LIME.

Lime in the form of carbonate of lime as in marl, wood ashes, etc., can usually be applied with safety in the spring or at any other season of the year, but autumn is always the safest time to apply caustic or slacked lime. The latter form changes gradually into carbonate of lime, which is not caustic, upon exposure to the air, but usually a considerable quantity has not yet reached that stage, when applied, and it may in consequence act too energetically. This is particularly true if the soil is light and sandy, and if plants, which are but little helped by lime, are employed. On very acid soils, particularly such as contain much humus, there is little or no danger from applying reasonable quantities of lime in the spring. If caustic or slacked lime is applied in excessive amounts it may not only injure plants directly but also indirectly by rendering the texture of the soil unfavorable; it may also make the soil temporarily so alkaline as to interfere with the activity of the organisms which transform ammonia into readily assimilable nitrates. Injury thus arising can not ordinarily be of long duration, for the reason that the carbonic acid of the soil changes the caustic lime rapidly into carbonate of lime, and thus the alkalinity of the soil is soon reduced.

HOW TO APPLY LIME.

Some writers recommend that upon old mossy meadows and pastures lime should be applied to the surface before plowing, in order that it may help to quickly decompose the organic matter. The chief objection to this procedure is that the lime does not become well incorporated with the soil, and since some of it is turned to the bottom of the furrow and its tendency at all times is to work downward, it may be quickly carried not only away from the surface soil, but also from the reach of plants. The practice of liming such soils immediately after plowing and then thoroughly harrowing has been attended by excellent results. This is particularly the case provided a second application is made in a similar manner, just previous to reseeding. Under such a plan some lime becomes intimately mixed with the entire mass of soil by the operations of tillage, and finally a considerable amount is left near the surface, thus accomplishing two important objects.

In some sections where marl is extensively used it is spread upon the surface and plowed under, turning a furrow about 2 inches deep. The more common method where marling is practiced is to plow the land and then cart on the marl, dumping it in heaps at such intervals that it can be spread conveniently with a shovel. If the marl is not sufficiently fine and is of such a nature that it crumbles upon exposure to the air, the heaps may be allowed to remain for some time before spreading, and still further time may be allowed to elapse before the operation of harrowing is begun. Sometimes a "clod crusher" or "bush harrow" may be employed to advantage to break up the lumps before harrowing. A most important point to be observed in applying lime in all of its forms is to mix it with the soil as thoroughly as possible, the finer the particles the better being the result.

Lime which is already slacked may be spread upon the soil directly from wagons or carts, or dumped in heaps and then spread with a shovel, though the most satisfactory plan in such cases is to employ an ordinary grain drill with fertilizer attachment or a lime spreader. In the use of such spreaders it is generally advisable to attach some burlap or old bagging to the sides and rear of the machine in such a way that it will trail upon the ground. If the machine is so equipped and the burlap is weighted with a piece of wood at the rear, much of the unpleasantness connected with spreading lime is avoided. For those familiar with the nature of lime and its use it is unnecessary to state that it is well, if possible, to apply it on a quiet day. The eyes may be protected by glasses and the nostrils and mouth by devices used by those who run threshing machines.

The only other form of lime in connection with the application of which any particular difficulty might be encountered is quick or burned lime. Where only small quantities of caustic lime are to be used it is frequently immersed for a moment in water, in a basket, and emptied into a wagon body. The following day it will be slacked sufficiently for use. Where larger quantities are used, and a lime spreader is at hand, the lime is sometimes water slacked in large piles on the border of the field and then distributed. To accomplish the water-slacking in a satisfactory manner, from 2 to 2½ pails of water should be sprinkled over each cask of lime as it is emptied upon the pile, and finally the whole mass should be very thoroughly covered with soil. In a few days practically all of the lime will be in a fine condition suitable for spreading. In loading it into the spreader care should be taken to first remove the soil, so as to avoid its clogging the machine. If the lime spreader itself is not fitted with a screen, the lime should first be carefully screened for the purpose of removing any hard lumps which may remain, due to imperfect slacking or burning. These lumps may be further slacked by themselves.

A practice preferred by many, and probably the most feasible one where a lime spreader is not to be had, is to place the burned lime in piles of from 35 to 40 pounds each at suitable intervals (heaps of this size 20 feet apart in each direction equals about 2 tons per acre), and cover the piles with moist earth. In a few days the lime is so thoroughly slacked that it can be spread directly with a shovel. Provided the soil is dry, from one fourth to half a pail of water (or in extreme cases even more) should be sprinkled over each pile immediately before it is covered with earth. In this case, as in all others where slacked lime is employed, it is important that it be harrowed into the soil immediately after spreading. In no case should it be exposed long to the air before harrowing, or it is liable to cake and form a sort of mortar, to such an extent that it is impossible to mix it as thoroughly with the soil as before.

FORMS OF LIME USED FOR AGRICULTURAL PURPOSES.

Caustic ("quick" or "burnt") lime obtained by burning oyster shells, limestone, etc., is the most economical form in which lime can be bought, in all cases where railway transportation is great or the material must be carted long distances. One hundred pounds of such lime usually contains about 95 pounds of actual lime. Sometimes burned lime contains considerable magnesia, a point which has already been considered (p. 7).

According to Roberts, "when first removed from the kiln, lime weighs about 75 pounds to the heaped bushel; that from shells weighs less than that from limestone. A ton of limestone converted into caustic lime (CaO) weighs between 1,100 and 1,200 pounds; hence it is economy to burn the lime near where the stones are quarried, since it weighs but three-fifths as much as limestone. In slacking, lime takes up considerable quantities of water; hence a ton of slacked or hydrated lime contains really but three-fourths as much lime as a ton unslacked. A heaped bushel of unslacked lime makes 1½ bushels of slacked lime;[1] therefore it should be transported before it is slacked. When caustic lime is exposed to the air for some time it absorbs moisture and carbonic acid from the atmosphere, and becomes air-slacked or carbonate of lime ($CaCO_3$), or limestone. It is now in the form of a fine powder, much finer than ground limestone." Lime made from oyster shells and magnesian limestone weighs less per bushel than that made from the purer kinds of limestone.

Gypsum or **land plaster** is a combination of lime with sulphuric acid (oil of vitriol) and water. Upon heating, gypsum loses its water and is changed into plaster of paris or calcined plaster, which is used in making casts and for many other industrial purposes.

In case a soil is seriously deficient in lime, gypsum may act as a direct manure; usually, however, its beneficial effect upon soils is attributed to its indirect action in liberating potash, and possibly other elements, which were locked up in the soil in such combinations that plants could not make use of them. Gypsum may be helpful to a limited extent on clayey soils by flocculating the fine particles, on account of which the soil is less likely to become "water-logged" and to cake and interfere with the operations of tillage. In the last-mentioned respect water-slacked lime or that in the form of carbonate is said to be much more efficacious than gypsum, though as a liberator of potash gypsum is claimed to lead.

It is stated on good authority that, in the presence of decaying organic matter, gypsum may be changed into carbonate of lime. While this may be true under certain circumstances, in experiments at the Rhode Island Station on a soil exceptionally rich in humus and containing a moderate amount of plant residues which were undergoing decomposition, such a change did not result, if at all, to a practical extent. For this reason and on account of the fact that gypsum contains only about one-third as much lime as burned lime, and usually costs as much or more per ton, it can not take the place of the latter for most purposes where lime is applied to land.

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[1] A bushel of air-slacked lime is usually considered to weigh 50 pounds.

For use in renovating "black alkali" (sodium carbonate) soils in the arid regions, gypsum, as already explained, performs a valuable function which can not be filled by any of the other forms of lime.

Chalk is a naturally occurring form of carbonate of lime which is exceptionally pure. It is quite soft, and is frequently referred to as marl.

Marl is a name which is applied to earthy deposits usually more or less friable in their character and containing carbonate of lime in quantities ranging usually from 5 to 95 pounds per 100 pounds of the material. It must be evident, therefore, that if one intends to make use of a given deposit of marl for the lime contained in it, he should first have a sample of it analyzed.[1] If the material will not effervesce upon the addition of vinegar, it probably contains but little carbonate of lime and may be of doubtful value. This test should precede, and not be substituted for, a careful chemical analysis.

On account of the varying chemical composition of marl, it must be obvious also that no definite rules as to the amounts which should be used in given cases can be stated. On a soil where one had reason to think a ton of burned lime should be applied per acre, about four tons of a marl containing from 20 to 25 per cent of actual lime (calcium oxid) should be employed. If the marl is twice as rich the amount applied should be but two tons, etc.

Marls vary somewhat in their physical characteristics, depending upon the amounts and character of the earthy material associated with the carbonate of lime. If the marl is associated with clay it is exceptionally well adapted for use on sandy soils, since the clay and carbonate of lime both tend to make such soils more compact and retentive of manures and moisture. A marl containing sand would, on the other hand, be better suited to clayey soils. According to Heinrich, sand marl may be applied to the soil immediately, but clay marls sometimes contain injurious compounds of iron and sulphur, in which case it is not safe to use them until they have been composted for two or three years, or long enough to effect the decomposition of the iron compounds.

Some so-called marls contain considerable quantities of phosphoric acid and potash in such forms as to greatly enhance their fertilizing value.

Phosphate of lime is found as bone, guano, apatite, and in the form of the well-known South Carolina, Florida, and Tennessee phosphate rock. The better classes of phosphate rock contain but small quantities of carbonate of lime, while others contain large amounts. The latter are unfitted on this account for superphosphate manufacture. Both classes of phosphate when ground finely have been found to be effective upon acid soils, particular attention having been devoted to their employment on acid muck or peat soils. They not only seem to materially reduce the acid character of such soils, but after having been in contact with the soil for some time the assimilability of the phosphoric acid seems to become materially increased. The lower-grade phosphates containing considerable quantities of carbonate of lime are particularly effective upon acid soils.

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[1] The experiment stations in the different States would probably undertake to do this free of cost.

In employing undissolved phosphate rock upon acid soils, good authorities recommend following the application of the phosphate at an interval of some months, or, if possible, a year, with a dressing of lime. This seems to be a reasonable recommendation in connection with certain plants which are indifferent to acid conditions.

Superphosphates, which are prepared by treating phosphate rock, bone, and boneblack with sulphuric acid, generally have about one-third of their lime combined with phosphoric acid and two-thirds with sulphuric acid. The lime combined with sulphuric acid is nothing more nor less than gypsum (land plaster). For this reason superphosphates frequently do not work as well on acid soil as ordinary undissolved phosphate rock or ground bone, and if, as is sometimes the case, a slight excess of sulphuric acid is present they may even exert an injurious action on soils devoid of carbonate of lime.

Basic slag (Thomas slag or slag meal) is a waste product obtained in the manufacture of steel. It contains relatively more lime than the ordinary high-grade phosphates, and the phosphoric acid in most cases (a few works have put an inferior product on the European market) is possessed of a high degree of assimilability. This product is as yet little known in this country, but if sold as cheaply as it might be it will doubtless prove of great value to our agriculture. It is an effective source of phosphoric acid for use upon all kinds of soils, and on account of its lime it is of special promise in the reclamation of exhausted acid soils, particularly such as are rich in organic matter, like many marsh or muck soils.

Unleached wood ashes contain about 35 pounds of actual lime (calcium oxid) in every hundred, three tons being, therefore, a little more than equivalent, in lime, to one ton of burned lime. They also contain from 5 to 7 per cent of potash, 1 to 2 per cent of phosphoric acid, and from 3 to 5 per cent of magnesia. This latter ingredient, though usually ignored, is, when not present in too great proportions, of approximately as much value as lime on acid soil. Magnesia is sometimes lacking in soils. When applied to such soils it seems to have a direct manurial action.

Leached wood ashes contain usually less than 1 per cent of potash and rather more lime than unleached ashes. Frequently they are sold in a wet condition, which of course lowers the quantity of actual lime present in a ton.

Limekiln ashes often contain approximately 40 per cent of lime, and when wood is employed in the burning instead of coal they sometimes contain 2 per cent or more of potash.

Finely ground limestone and oyster shells can be used to advantage, if obtainable, but they are not as efficacious as after burning, for the reason that they are not so active chemically, nor can they be reduced to so fine a state before burning as afterward.

Dye-house lime usually contains only a small percentage of lime, and if moist can not be transported long distances at a profit. A rule that applies well to this and all other waste products of a similar character is not to use them until they have been subjected to chemical analysis, for by changes in processes of manufacture their value may be materially influenced and substances injurious to vegetation may have found access to them.

Gas-house lime.—It is never safe to use this substance until it has first been allowed to weather for several months. On acid soils lime in this form is less effective than that in form of burned lime, wood ashes, and limekiln ashes. Owing to recent changes in the process of gas manufacture, lime is less used than formerly.

Waste lime from beet-sugar factories may be effectively applied to soils after it has been allowed to dry. It contains some potash, phosphoric acid, and nitrogen, which still further increases its value. If this material is applied to the soil in a wet condition, it tends to cake in the same manner as water-slacked lime does when not immediately worked into the soil. It is sometimes put in piles by itself and worked over every few weeks. It may also be dumped in the field during the winter in small piles, where it is allowed to remain until spring, when, after drying sufficiently, it may be spread and incorporated into the soil. According to Heinrich, this material contains: Water, 35 to 60 per cent; nitrogen, 0.1 to 0.4; potash, 0.1 to 0.3; phosphoric acid, 0.5 to 1.5, and lime, 15 to 30 per cent. It is evident that this waste material in its moist condition could not be transported to any considerable distance at a profit, and in this country, where labor is such an important item, it would not pay to shovel it over much in order to get it into condition to use.

Waste lime from soda-ash works usually contains considerable water, and can for this reason only be employed to advantage where the cost of transportation is small. If some economical means of drying it could be devised, the range of distance to which it could be profitably shipped would be much increased.

From the preceding statements regarding the different forms of lime used for agricultural purposes it is evident that it is impossible to state definitely for all locations and conditions which form is most economical to employ. The character of the soil and of the crop to be grown, as well as the market prices prevailing, must be taken into account, as well as the form of lime. Caustic or quicklime is the most concentrated form, and consequently the most economical to handle. Its caustic properties, however, render it more vigorous in its action than the milder sulphate (gypsum) or carbonates (limestone, chalk, wood ashes, marl, etc.), and thus better suited for application to soils which are rich in organic matter than to poor soils deficient in this substance. For the same reason, however, it is especially suited to correcting acidity in sour soils. There may be special reasons in particular cases, however, why some of the other forms of lime are preferable to quicklime. Gypsum has been used to a considerable extent with very satisfactory results. On account of its peculiar composition it has been found especially valuable for neutralizing sodium carbonate (black alkali) in alkali soils. Wood ashes are extensively used in some localities, in many cases as much for the lime as for the potash which they contain. It is very doubtful, however, whether it would not be more economical, at the present prices of wood ashes and caustic lime, to employ the latter in the majority of cases, supplementing the lime with potash salts and other fertilizing materials if the latter are required by the soil.[1] The item of transportation is also decidedly in favor of the use of lime and fertilizer chemicals as substitutes for ashes.

SUMMARY.

The use of lime as a soil improver is very ancient, and its value for this purpose is generally recognized. Its action as a fertilizer is both direct and indirect.

There are many soils in which lime is deficient, notably in soils derived from granite, mica schist, and sandstone formations. On such soils lime is of direct value in supplying a necessary element of plant food.

The indirect value of lime is perhaps more important than its direct action, because probably the majority of cultivated soils contain sufficient lime to meet the direct demands of plants. Lime is of indirect value in unlocking the unavailable potash, phosphoric acid, and nitrogen in the soil.

Lime exerts a decided influence on the mechanical condition of soils, rendering heavy compact soils looser in texture and tending to bind particles of loose leachy soils.

Lime is also beneficial in furnishing conditions in the soil favorable to the activity of the micro-organisms which convert the nitrogen of organic matter into nitrates which are readily assimilated by plants, which decompose organic matter, and which assist leguminous plants to assimilate the free nitrogen of the air.

One form of lime, gypsum, has been shown to be a most effective corrective of black alkali, found in some of the soils of the arid portions of the United States.

The continued use of lime unaccompanied by other fertilizers may prove injurious, especially on poor soils, since it converts the insoluble nitrogen, potash, and phosphoric-acid compounds of the soil into forms which are rapidly taken up by plants or washed out in the drainage, and thus hastens the exhaustion of the supply of these substances in the soil. As the German adage states, "The use of lime without manure makes both farm and farmer poor." If the soil is not abundantly supplied with organic matter, its retentive power for water and fertilizers may be seriously reduced on account of the destruction of the organic matter by the action of too much lime. Soils are sometimes injured by applications of impure forms of lime, which harden like cement in the soil, or of those which contain an excessive amount of magnesia.

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[1] U. S. Dept. Agr., Farmers' Bul. 65 (Experiment Station Work—II), p. 24.

It has been shown that even many upland and naturally well-drained soils apparently in good condition otherwise are so sour (acid) that most plants will not thrive on them. The application of caustic lime is the most economical and effective means of correcting this condition. According to experiments made by the Rhode Island Experiment Station on acid soils in that State, the plants tested may be classified with regard to their behavior toward lime as follows: Plants benefited by liming—spinach, lettuce, beets (all kinds), gumbo (okra), salsify (vegetable oyster), celery, onion, parsnip, cauliflower, cucumber, eggplant, cantaloupe, asparagus, kohl-rabi, cabbage, dandelion, Swedish turnip, pepper, pea, peanut, martynia, tobacco, sorghum, alfalfa, clover, barley, wheat, oats, timothy, and Kentucky blue grass; plants injured by liming—serradella, watermelon, blue lupine, and common sorrel (*Rumex acetosella*); plants indifferent to liming—Indian corn, common millet, Hungarian, golden millet, rye, potatoes, carrots, Rhode Island bent (grass), and redtop (grass).

Lime may be applied in a variety of forms, among which are caustic, or burnt lime, or quicklime, which should contain at least 90 per cent of actual lime (CaO) and is the most concentrated form of this material; gypsum, or land plaster, in which the lime is in the form of the mild sulphate; ground limestone and chalk, in which the lime is in the form of the mild carbonate; different kinds of marl, containing varying proportions of sand and clay and from 5 to 95 per cent of carbonate of lime; wood ashes, which contain from 30 to 35 per cent of lime in the form of carbonate; limekiln ashes, containing about 40 per cent of lime; and waste lime from gas houses, sugar-beet factories, etc., the composition of which varies with the process of manufacture.

It is impossible to state definitely for all locations and conditions what form of lime is cheapest to use. Caustic, or quicklime, is the most concentrated form and consequently the most economical to handle. On account of its caustic properties it is more vigorous in its action than the milder sulphate (gypsum) or carbonates (limestone, chalk, wood ashes, marl, etc.). There may be special reasons, however, why some of the latter forms may be preferable. For instance, gypsum, on account of its peculiar composition, has been found to be a specially valuable corrective of black alkali.

The frequency with which liming should be practiced depends, among other things, upon the character of the soil and the rate of application, the number of years involved in the rotation practiced, the plants grown and their order of succession. As a general rule, it may be stated that from one-half to 1½ tons of lime per acre every five or six years is sufficient. Applications of two or three tons may, however, be advisable in case of very acid soils which are to be seeded down and to remain in grass for several years. The practice of applying small amounts of lime at somewhat frequent intervals is being generally accepted as preferable to the use of large amounts at rare intervals.

Lime in the form of carbonate of lime, as in marl, wood ashes, etc., can usually be applied with safety in the spring or at any other season of the year, but autumn is always the safest time to apply caustic or slacked lime. It is generally considered best to apply the lime to the soil immediately after plowing and harrow in thoroughly. Lime which is already slacked may be spread upon the soil directly from wagons or carts, or dumped into heaps and then spread with a shovel, although the most satisfactory plan in such cases is to use a lime spreader or ordinary grain drill with fertilizer attachment. Where a lime spreader or similar implement is not available the burnt lime may be placed on the soil in piles of from 40 to 50 pounds each, covered with moist earth, and allowed to slack before being spread with a shovel. Marls frequently contain injurious compounds and should therefore be allowed to weather for some time in the field before being incorporated with the soil. The same is true of gas-house lime, which is impregnated with sulphur compounds which are injurious to plants.

In conclusion it may be said, ascertain first whether lime is needed. If it is, apply it judiciously, and never depend upon lime alone to maintain the fertility of the soil, for all of the ingredients which plants need must be present in the soil to insure the profitable production of crops.

FARMERS' BULLETINS.

The following is a list of the Farmers' Bulletins available for distribution, showing the number, title, and size in pages of each. Copies will be sent to any address on application to Senators, Representatives, and Delegates in Congress, or to the Secretary of Agriculture, Washington, D. C.:

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71. Essentials in Beef Production. Pp. 24.
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73. Experiment Station Work—IV. Pp. 32.
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75. The Grain Smuts. Pp. 20.
76. Tomato Growing Pp. 30.
77. The Liming of Soils. Pp. 19.
78. Experiment Station Work—V. Pp. 32.
79. Experiment Station Work—VI. Pp. 28.
80. The Peach Twig-borer. Pp. 16.
81. Corn Culture in the South. Pp. 24.
82. The Culture of Tobacco. Pp. 24.
83. Tobacco Soils. Pp. 23.
84. Experiment Station Work—VII. Pp. 32.
85. Fish as Food. Pp. 30.
86. Thirty Poisonous Plants. Pp. 32.
87. Experiment Station Work—VIII. Pp. 32.
88. Alkali Lands. Pp. 23.
89. Cowpeas. Pp. 16.
90. The Manufacture of Sorghum Sirup. Pp. 32.
91. Potato Diseases and Their Treatment. Pp. 12.
92. Experiment Station Work—IX. Pp. 30.
93. Sugar as Food. Pp. 27.
94. The Vegetable Garden. Pp. 24.
95. Good Roads for Farmers. Pp. 47.
96. Raising Sheep for Mutton. Pp. 48.
97. Experiment Station Work—X. Pp. 32.
98. Suggestions to Southern Farmers. Pp. 48.
99. Three Insect Enemies of Shade Trees. Pp. 30.
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102. Southern Forage Plants. Pp. 48.
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113. The Apple and How to Grow It. Pp. 32.
114. Experiment Station Work—XIV. Pp. 28.
115. Hop Culture in California. Pp. 27.
116. Irrigation in Fruit Growing. Pp. 48.
117. Sheep, Hogs, and Horses in the Northwest. Pp. 28.
118. Grape Growing in the South. Pp. 32.
119. Experiment Station Work—XV. Pp. 31.
120. The Principal Insects Affecting the Tobacco Plant. Pp. 32.
121. Beans, Peas, and other Legumes as Food. Pp. 32.
122. Experiment Station Work—XVI. Pp. 32.
123. Red Clover Seed. Pp. 11.
124. Experiment Station Work—XVII.
125. Protection of Food Products from Injurious Temperature. Pp. 26.

U. S. DEPARTMENT OF AGRICULTURE.

FARMERS' BULLETIN No. 78.

Experiment Station Work–V.

HUMUS IN SOILS.
SWAMP, MARSH, OR MUCK SOILS.
RAPE.
VELVET BEAN.
SUNFLOWERS.
WINTER PROTECTION OF PEACH TREES.
SUBWATERING IN GREENHOUSES.
BACTERIAL DISEASES OF PLANTS.
GRAPE JUICE AND SWEET CIDER.

PREPARED IN THE OFFICE OF EXPERIMENT STATIONS.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1898.

CONTENTS OF THE SERIES OF FARMERS' BULLETINS ON EXPERIMENT STATION WORK.

I. (Farmers' Bul. 56).—Good vs. Poor Cows; Corn vs. Wheat; Much vs. Little Protein; Forage Crops for Pigs; Robertson Silage Mixture; Alfalfa; Proportion of Grain to Straw; Phosphates as Fertilizers; Harmful Effects of Muriate of Potash; Studies in Irrigation; Potato Scab; Barnyard Manure.

II. (Farmers' Bul. 65).—Common Crops for Forage; Stock Melons; Starch in Potatoes; Crimson Clover; Geese for Profit; Cross Pollination; A Germ Fertilizer; Lime as a Fertilizer; Are Ashes Economical? Mixing Fertilizers.

III. (Farmers' Bul. 69).—Flax Culture; Crimson Clover; Forcing Lettuce; Heating Greenhouses; Corn Smut; Millet Disease of Horses; Tuberculosis; Pasteurized Cream; Kitchen and Table Wastes; Use of Fertilizers.

IV. (Farmers' Bul. 73).—Pure Water; Loss of Soil Fertility; Availability of Fertilizers; Seed Selection; Jerusalem Artichokes; Kafir Corn; Thinning Fruit; Use of Low-grade Apples; Cooking Vegetables; Condimental Feeding Stuffs; Steer and Heifer Beef; Swells in Canned Vegetables.

LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
OFFICE OF EXPERIMENT STATIONS,
Washington, D. C., April 15, 1898.

SIR: The fifth number of Experiment Station Work, prepared under my direction, is transmitted herewith with the recommendation that it be published as a Farmers' Bulletin.

Respectfully,
A. C. TRUE,
Director.

Hon. JAMES WILSON,
Secretary of Agriculture.

CONTENTS.

Page.
Fraud in fertilizers........ 5
Sugar-beet industry in the United States........ 8
Seeding grass land without a nurse crop........ 11
Grafting apple trees........ 12
Forest fires........ 16
American clover seed........ 17
Mushrooms as food........ 18
Pasturing pigs on stubble fields........ 20
Ensiling potatoes........ 21
Anthrax........ 23
Explanation of terms........ 26
    Terms used in discussing fertilizers........ 26
    Terms used in discussing foods and feeding stuffs........ 26
    Miscellaneous terms........ 27

ILLUSTRATIONS.

Fig. 1. Different-shaped beets........ 10
    2. Root graft of apples........ 15

EXPERIMENT STATION WORK—VI.[1]

FRAUD IN FERTILIZERS.

The value of commercial fertilizers annually used in the United States is estimated at from $35,000,000 to $40,000,000. The fertilizer industry in this country has grown to these proportions within fifty years. It was but natural that a business growing so rapidly and offering such opportunities and temptations for fraud and imposition should have early become a field for extensive operations of unscrupulous and dishonest men. Fraud became so prevalent as the industry developed in one State after another that there was an urgent demand both from the consumers of fertilizers and from honest manufacturers and dealers in fertilizers for laws providing for the inspection of fertilizers with a view to the prevention or the detection and punishment of fraud. Every State in which commercial fertilizers are used to any great extent has now provided for such inspection (see p. 7). The work in the majority of cases has been assigned to the agricultural experiment stations of the different States and forms one of their most important and exacting duties. In some cases the stations cooperate with the State boards of agriculture, while in a few instances the inspection is entirely in the hands of the latter or of the State chemist. Thousands of analyses of fertilizers are made and reported by the inspection officials each year, accompanied in most cases by general information relating to fertilizers. These reports may usually be had on application to the proper officials (see p. 7).

This system of inspection has been very effective in repressing fraud, but it has by no means eliminated it from the fertilizer business. The man who peddles a worthless "formula" at an exorbitant price or exploits under a high-sounding name a mixture which has little or no value as a fertilizer is still abroad in the land.

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[1] This is the sixth number of a subseries of brief popular bulletins compiled from the published reports of the agricultural experiment stations and kindred institutions in this and other countries. The chief object of these publications is to disseminate throughout the country information regarding experiments at the different experiment stations, and thus to acquaint our farmers in a general way with the progress of agricultural investigation on its practical side. The results herein reported should for the most part be regarded as tentative and suggestive rather than conclusive. Further experiments may modify them, and experience alone can show how far they will be useful in actual practice. The work of the stations must not be depended on to produce "rules for farming." How to apply the results of experiments to his own conditions will ever remain the problem of the individual farmer.—A. C. TRUE, Director, Office of Experiment Stations.

As a bulletin of the Maine Station states—

> There are two claims which generally characterize the representations of the companies and agents selling these questionable goods:
>
> (1) The process of manufacture is a secret one, having been "discovered" by some one who is generally unknown either to science or practice.
>
> (2) The "fertilizer," or "food," either contains ingredients of which the whole world, outside of a favored few, is ignorant, or else certain ingredients are so wonderfully compounded as to produce marvelous results.

The inspectors of fertilizers report examples of this from all parts of the country. The mere existence of such "business" proves that in spite of the work of inspection officials there are still persons who allow themselves to be imposed upon by extraordinary claims or plausible representations. There is abundant evidence that through credulity, lack of accurate knowledge, and hasty judgment the farmers of the country suffer to a considerable extent each year at the hands of "agents" of such business.

As the Maine Station bulletin already quoted states, "in too many instances the goods are first bought for cash or on credit, invariably at an unusually large price, and then after the act is past recalling information is sought as to the character and value of the 'fertilizer' or 'food' purchased. If accurate information were first obtained in these cases, there would be less of these transactions where value is not received for the money paid." Such information can always be had for the asking from the agricultural experiment stations or from the officials charged with the inspection of fertilizers in the different States. (See list on p. 7.)

In a recent bulletin relating to a fraudulent fertilizer "formula," the North Carolina Station says:

> The farmers of the State are urgently advised not to pay any money for fertilizing formulas, as the station is ready and willing to suggest any mixture for any crop, using any materials at hand or most convenient to be had. It has in the past distributed many hundreds of these formulas, and is distributing them every day. These formulas are sent entirely free, and are made up in proportions that are known to be correct, not only from a scientific but a practical standpoint. Of what earthly use is it to buy from a man, at a high price, a set of figures which nine times out of ten is incorrect and, even if correct, could be had by application to the station without cost?

There is a large class of fertilizers on the market which are not strictly fraudulent, although extravagant claims are made for them. They are often sold at low prices but are nevertheless very expensive. They are sold at low prices because they contain very small amounts of fertilizing constituents in the form of low-grade materials, the greater part of the mixture being worthless makeweight. It may be laid down as a general rule that such low-grade fertilizers are actually more expensive than high-grade goods. It costs just as much to mix, bag, and ship a ton of material furnishing 50 pounds of actual fertilizing constituents (phosphoric acid, potash, and nitrogen) as it does the same amount of a fertilizer furnishing 500 pounds of valuable constituents. The farmer therefore must be guided not by the price per ton, but by the actual amounts of fertilizing constituents which the fertilizer contains and the requirements of his own crops and soils.

The purchaser of fertilizers is generally, but not always, justified in regarding with suspicion a fertilizer for which extraordinary claims are made. While the best fertilizing materials—superphosphates, potash salts, nitrates and ammonia salts, industrial by products such as tankage, dried blood, cotton-seed meal, etc.—have become standard articles of commerce and there is no good reason why fertilizers compounded from them should not stand on their merits and be sold under easily understood names, absurd names and extravagant claims have in many cases cast suspicion upon mixtures of these standard articles which are really high-grade fertilizers. This practice partakes of the nature of quackery, and, as Dr. C. W. Dabney has stated, "the nostrum excites the suspicion of the sensible man; the staple article inspires his confidence." For this reason, as Dr. Dabney further states—

> Farmers who take their life work seriously and study earnestly the experimental work of the State stations, for the purpose of informing themselves with regard to the useful ingredients of fertilizers, the proper method of applying them, and such matters, * * * are getting more and more into the habit of buying the raw materials for fertilizers and mixing them themselves, or else they have a compound mixed at a factory according to their own formula and from materials of their own selection.

For the convenience of those desiring information and advice regarding fertilizers the following list of official inspectors of fertilizers is given:

Official inspectors of fertilizers.

Alabama.—Commissioner of Agriculture, Montgomery.
Arkansas.—State Chemist, Arkansas Industrial University, Fayetteville.
Connecticut.—Director, Agricultural Experiment Station, New Haven.
Delaware.—State Chemist, Delaware College Agricultural Experiment Station, Newark.
Florida.—Commissioner of Agriculture, Tallahassee.
Georgia.—Commissioner of Agriculture, Atlanta.
Illinois.—Secretary of the Board of Agriculture, Springfield.
Indiana.—State Chemist, Purdue University, Lafayette.
Kentucky.—Director, Agricultural Experiment Station, Lexington.
Louisiana.—Commissioner of Agriculture and Immigration, Baton Rouge.
Maine.—Director, Agricultural Experiment Station, Orono.
Maryland.—State Chemist, Maryland Agricultural Experiment Station, College Park.
Massachusetts.—State Chemist, Hatch Agricultural Experiment Station, Amherst.
Michigan.—State Chemist, Michigan Agricultural College, Agricultural College.
Mississippi.—State Chemist, Mississippi Agricultural and Mechanical College, Agricultural College.
Missouri.—Director, Agricultural Experiment Station, Columbia.
New Hampshire.—Secretary of the State Board of Agriculture, Concord.

New Jersey.—Director, New Jersey Agricultural Experiment Station, New Brunswick.
New York.—Director, New York Agricultural Experiment Station, Geneva.
North Carolina.—Commissioner of Agriculture, Raleigh.
Ohio.—Secretary of the Board of Agriculture, Columbus.
Pennsylvania.—Secretary of Agriculture, Harrisburg.
Rhode Island.—Secretary of the Board of Agriculture, Providence.
South Carolina.—Secretary, Fertilizer Department, Clemsón College.
Tennessee.—Commissioner of Agriculture, Nashville.
Vermont.—Director and Chemist of the Agricultural Experiment Station, Burlington.
Virginia.—Commissioner of Agriculture, Richmond.
West Virginia.—Director, West Virginia Agricultural Experiment Station, Morgantown.
Wisconsin.—Chief Chemist, Agricultural Experiment Station, Madison.

THE SUGAR-BEET INDUSTRY IN THE UNITED STATES.

Sugar is a prime necessity in every household. In 1896 the United States consumed about 1,960,000 tons of sugar, or about 62 pounds per head annually. Of this amount over 1,670,000 tons came from abroad. The desire to meet, at least in part, this enormous demand for sugar by home production has led to efforts by the Department of Agriculture, the experiment stations, and similar institutions to demonstrate the feasibility of supplementing the sugar industry of Louisiana by a sugar-beet industry. As a result of these efforts the culture of sugar beets for sugar-making purposes is receiving widespread attention in the United States at the present time. Many of the experiment stations have carried on experiments in the culture of sugar beets for several years past with very encouraging results, and at present a large majority of the stations in the country are studying the subject. The experiment stations of Arizona, Colorado, Illinois, Indiana, Iowa, Kansas, Michigan, Missouri, New York, Ohio, Oregon, Pennsylvania, South Dakota, Utah, Washington, Wisconsin, and Wyoming have recently issued bulletins on the subject of sugar beets. The United States Department of Agriculture has cooperated with the stations in this work and has just reported the results of experiments during 1897 in almost every State and Territory.

These experiments have shown that there are wide areas in the United States adapted by soil and climate to the growth of sugar beets. While the beet has generally attained its greatest perfection in what are called north temperate latitudes, the tests which have been made in different parts of the United States show that the lines must not be drawn too closely in this respect. Beets of excellent quality have been grown in regions having very dissimilar climates. For a large part of the United States the amount and distribution of rainfall or other supplies of water seem more important considerations than the temperature. An average of 2 to 4 inches of water per month during the summer is considered necessary for the normal growth of beets, but it is especially important that the weather should remain dry during the ripening and harvesting of the beets, otherwise new growth will start and the sugar rapidly disappear. Where irrigation is practiced the water supply is, of course, under control, and experiments in the irrigated region of the United States have shown that beets of fine quality can be produced with an artificial water supply. The Colorado Station has found that in order to secure good beets the last irrigation should be made about six weeks before maturity.

"In general it may be said that any soil which will produce a good crop of Indian corn, wheat, or potatoes will, under proper cultivation, produce a good crop of sugar beets. The soil on which sugar beets are grown, however, should be reasonably level, and this being the case it should be well drained." The draft of the sugar beet upon the soil is not great provided the tops and factory by-products are returned to the farm.

The varieties of beets which have been most widely tested and have given the most satisfactory results are White Improved Vilmorin and Kleinwanzlebener. Seeds are now imported almost exclusively, but farmers and seedsmen might profitably turn their attention to the raising of seed.

It is not the purpose of this article to enter in detail into methods of culture. These are explained in full in a bulletin of this Department.[1] It suffices to state here that the object kept constantly in mind should be the production of a beet of a high sugar content and paying yield. It must always be borne in mind that the largest beets are not the sweetest. Any undue increase in the size is almost sure to be accompanied by a decrease in sugar content. Beets weighing from 1 to 2 pounds are considered the best for sugar making. When beets are paid for by the ton it is of course to the farmer's advantage to secure as large a yield as possible, but the manufacturer at the same time has a right to demand that quality shall not be sacrificed to size, and that the beets which he buys shall contain a sufficiently high percentage of sugar to make manufacture profitable.

In order to secure such beets it is absolutely essential to deeply and thoroughly prepare the soil. No fact has been more clearly brought out by experiment than this. "It is of the highest importance that the land intended for beet raising should be plowed deeply enough to permit the beet to develop its normal shape and still not protrude above the ground. The soil should be loosened to a depth of not less than 15 inches."[2] It is probable that neglect to observe this precaution has been responsible for a large part of the failures to produce beets of good quality which have been reported from different localities. Some of the effects of an improperly prepared soil are shown in the accompanying illustration on page 10 (fig. 1).

From what has been said it is evident that there must be mutual understanding and cooperation between the farmer and the manufacturer. As soon as farmers in a given locality can demonstrate their ability to grow a beet of high sugar content and will bind themselves to supply such beets in the necessary quantities, manufacturers will not be slow to establish factories wherever the other conditions (of location, transportation, etc.) are favorable. "The manufacture of beet sugar is an industry entirely distinct from agriculture, and can only be successfully accomplished by the investment of large capital under the direction of skilled artisans. From the nature of the process it is quite improbable that any simple method of home manufacture of beet sugar will ever prove commercially successful. * * * The farmers of this country, as is the case with those of Europe, in respect of the beet-sugar industry, must be satisfied with acquiring the requisite degree of agricultural skill to produce a crop of beets with a paying tonnage and a high content of sugar."[1]

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[1] U. S. Dept. Agr., Farmers' Bul. 52.

[2] Indiana Sta. Bul. 68.

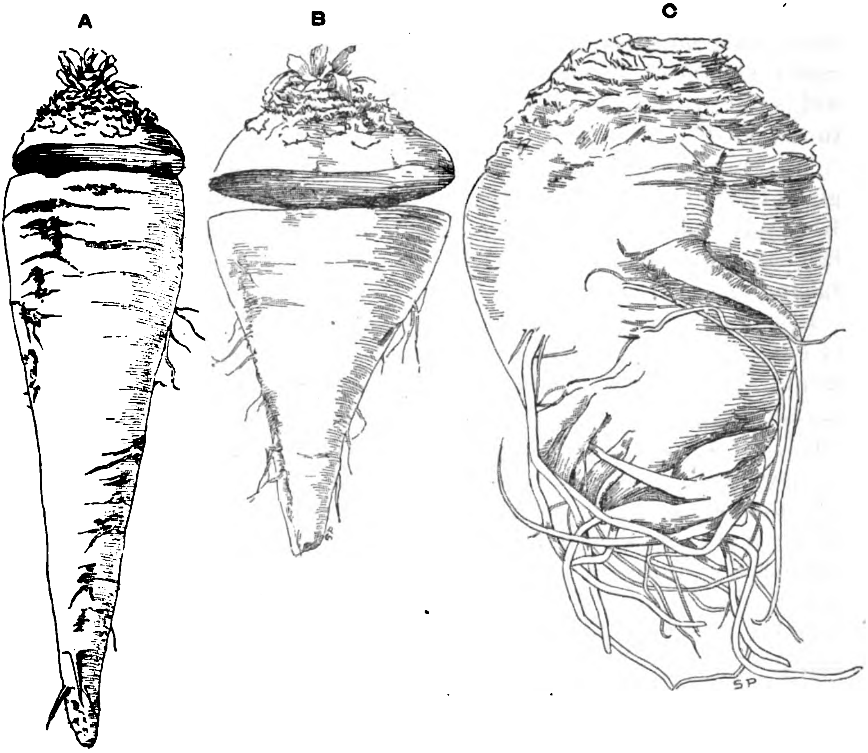

FIG. 1.—Different-shaped beets: *A*, a well-shaped beet grown in good soil with a porous subsoil, 15 per cent waste in trimming; *B*, a poorer-shaped beet, the result of a hard subsoil or other unfavorable conditions which caused the root to grow mostly near or above the surface of the ground, 33 per cent waste in trimming; *C*, a very large beet grown in rich soil and well tilled, but subsoil too hard and beets allowed too much room. (Adopted from New York Cornell Station Bul. 143.)

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[1] U. S. Dept. Agr. Farmers' Bul. 52

In order that the sugar-beet industry may be successfully established in the United States it will be necessary to determine definitely the regions especially adapted to the beet and to confine its culture to those areas. It will also be necessary for the farmer to learn and practice methods of culture which will produce a beet of high sugar content and fair yield per acre. As a bulletin of the New York State Station states, "Farmers may not expect to realize unusual profits for any long period of time from the growing of sugar beets. The crop promises to become one which will give satisfactory returns to those who learn to grow it successfully."

As a recent bulletin of the Pennsylvania Station shows, the estimates which have been made of the cost of raising sugar beets are very variable, ranging from $20 to $70 per acre. A conservative estimate is probably $30 to $40 per acre, although the cost of production will naturally depend upon local conditions, and especially upon the experience and intelligence of the grower. The general experience has been that the second year's crop is more cheaply produced than that of the first year. If $4 be assumed as an average price per ton for the beets, and the yield from 10 to 15 tons, the total value of the crop at the factory would range from $40 to $60 per acre. To this should be added the value of the diffusion residue or pulp from the factory which forms a palatable and nutritious food for stock.

Farmers can well afford to undertake experiments with sugar beets on a limited scale for the purpose of familiarizing themselves with methods of culture and of determining the adaptability of their soils to the production of beets. Even if factories are not established to work up this product it can be utilized to advantage on the farm, since the beets form a valuable food for stock.

SEEDING GRASS LAND WITHOUT A NURSE CROP.

The practice of sowing grass and clover seed with crops of grain is a very common one and undoubtedly has many advantages on rich soils and in a favorable season, the most marked of which is the choking out of weeds by the vigorous growth of the grain. In many cases, however, this method fails. Especially is this true in dry seasons when the supply of moisture is frequently insufficient for both the grain crop and the grass. In this case the grain instead of acting as a nurse crop actually robs the young grass plants of moisture, and thus becomes injurious instead of advantageous.

The claim that grass and clover plants need protection from the sun is entirely without foundation. As the Wisconsin Station has shown, "there is absolutely no necessity, under ordinary conditions, for sowing oats, barley, or any other grain with grasses for the purpose of yielding shade and protection. Young grass and clover plants are not injured by direct sunlight and sun heat any more than other plants of our fields."

Experiments by the Wisconsin Station during a number of years have shown that "grasses and clover sown by themselves on properly prepared soil spring up at once and make rapid growth, bearing seed heads the same year. If all conditions as to fertility of soil, moisture, etc., are favorable, a very excellent crop of hay can be secured the same season." One objection to this method of seeding grasses is the presence of weeds, but these can usually be checked by running a mower over the fields when the weeds are 6 or more inches high, setting the cutter bar so that the tops of the weeds are removed while the grass plants are not touched.

In order that this method of culture may be successful the soil must be quite free from weed seeds and of fair fertility. It should be carefully prepared before seeding and from two to three times the usual amount of grass seed should be sown. It is probably best, although not fully demonstrated, to sow seed very early in the spring. Finally, it is of the greatest importance to check the growth of weeds, which may be done by the method noted above.

"The system here under consideration is not put forth as suited to every farm and all farmers, but eminently adapted to meeting the wants of those who desire to secure with the least possibility of failure a fine stand of grass and clover. To such we can recommend the system as having been sufficiently tried to prove satisfactory when properly followed out."

The results obtained by the Wisconsin Station have in general been borne out by those of similar experiments at the New Jersey Station. The experiments by this station, however, differed from those conducted by the Wisconsin Station in the fact that at the former the seed was sown in the fall instead of in the spring.

GRAFTING APPLE TREES.

Probably no topic connected with apple growing has received more discussion than the methods of grafting, the most diverse opinions being held by nurserymen and apple growers. The Kansas Station has recently reported experiments in which some important points in regard to root grafting apples were brought out. The object of the work was to determine the relative merits of various lengths of stock and scion, and of various positions of the graft on the stock. The tests were carried through a number of years and in all several thousand grafts were made. The stocks used were all No. 1 seedlings, most of which were regraded to get a uniform lot. The scions were also as uniform as possible.

In the first experiment 6-inch Ben Davis scions were grafted on different parts of roots. The tops of seedlings were cut off below the crown and the roots cut into three pieces. One hundred grafts were made with the upper parts of the roots, 100 with the middle parts, and

100 with the lower parts or tips of the roots. About 80 per cent of the grafts made with the upper and middle parts of the roots grew and at one and two years old there was little difference between the trees grown from them. Of the grafts made with the root tips only 60 per cent grew. The first season the trees of this lot averaged one-third less in height than the other lots and were more slender and weak. The second year the difference was less marked. The same year that the above experiment was begun 100 Ben Davis scions 2 feet long were grafted on the upper parts of roots cut below the crown. At two years old these trees were about one-half larger and stronger than the trees from 6-inch scions on similar stocks. Many of the tops were so heavy as to necessitate summer pruning.

In 1893 more extensive experiments were made. Wine Sap, Missouri Pippin, Ben Davis, and Maiden Blush apples were used in each series of grafts made. Three lengths of scions, 6, 12, and 24 inches, were used. With each kind of scion four lengths of stocks were used, namely, piece roots, 1¼, 2½, and 5 inches long, and whole roots. For all piece-root grafts the upper parts of roots were used. In all cases except where 1¼-inch stocks were used one-half of the grafts were made 1 inch above the crown and the other half below the crown. Besides the above, a number of grafts were made on 2½-inch piece roots of small size. In all, 9,200 grafts were made. The grafts were set in nursery rows, with the place of union of stock and scion in all cases about 3 inches below the surface of the soil. The percentage of loss was great, owing to the very unfavorable spring and to the grafts having been stored in a cellar which was too warm. The loss with the whole root grafts was least and increased as the length of the root diminished. About 82 per cent of the whole-root grafts were living at the end of the first year, as against only about 49 per cent of the 5-inch, 17 per cent of the 2½-inch, 11 per cent of the small 2½-inch, and 6 per cent of the 1¼-inch piece-root grafts. From measurements made at the end of the third season it was shown that the greatest growth was made in trees grafted on the longest stocks and that the growth declined gradually, though slightly, with the shorter stocks, being about 11 per cent greater with the whole root than with the 1¼-inch piece-root grafts. The trees also showed a tendency to make the best growth from the longest scions, the growth being 11 per cent greater with the 24-inch scions than with the 6-inch ones. There was no constant difference in growth between the trees grafted above the crown and those grafted below it.

In 1894 the above experiment was repeated in part with Wine Sap, Ben Davis, and Missouri Pippin apples, using 6, 12, and 24 inch scions on whole roots and 5-inch piece-root stocks grafted above and below the crown. After two years' growth there was no constant difference between the trees grafted above the crown and those grafted below, either as regards height or diameter. The length of the stocks and scions had a marked influence on the growth, the difference in favor of the long stocks and long scions being practically constant in all cases. The height of 2-year-old trees grafted on whole roots averaged 21 per cent greater than on 5-inch stocks and the diameter over 3 per cent greater. Trees from 24-inch scions averaged 10 per cent higher than from 12-inch scions and 20 per cent higher than those from 6-inch scions. Their diameters were 27 per cent greater than the trees from 12-inch scions and 34 per cent greater than those from 6-inch scions. These differences were not nearly so marked after the trees had made three years' growth, the diameter of the trees from 24-inch scions at that time averaging only 6 per cent greater than those from the 12-inch scions and only 7 per cent greater than those from the 6-inch scions, as against 27 per cent and 34 per cent, respectively, after two years' growth.

In 1895 grafts were made with 12 and 6 inch scions on whole roots, 5-inch roots, and 2½-inch roots, grafted above and below the crown. In addition, a stock grafted above the crown, with roots cut 8 inches long, was tested. After two years' growth no constant differences were shown in favor of either length or style of stock or of grafting either above or below the crown. The trees from 12-inch scions were invariably greater in height and diameter than those from 6-inch scions.

An experiment in root grafting was made by F. Wellhouse, president of the Kansas Horticultural Society. About 400 trees each of Wine Sap, Ben Davis, and Missouri Pippin apples, grafted on whole-root stocks, were set in the orchard together with trees grafted on 2-inch piece-root stocks. During nineteen years no difference in growth, vigor, or fruitfulness was observed between them, except that for the first six or eight years the whole-root trees threw up from their roots more water sprouts than the piece-root trees.

These tests show that there are fairly uniform differences in the first few years' growth of trees in favor of the longer scions and stocks, but that by the end of the third year's growth the differences largely disappear, and that there is no constant difference between trees grafted above and those grafted below the crown.

Besides the observations on the height and diameter of trees, the Kansas Station has also reported a study of the root development of grafted trees. It was found that the main root growth of the first year from all lengths of stock was made at or just below the union of the stock and scion, and that the growth at this point became more pronounced in the second and third years. The growth from the lower portion of the stock was very slight during the first year, and became of even less importance during the second and third years; the growth from the lower part of the stock was greatest in case of the shorter piece roots and least in case of the whole roots. With grafts that were buried deeply, a new system of side roots formed at about the usual depth below the surface of the soil, to the more or less complete dwarfing of the lower and earlier root system. This is shown in fig. 2, which represents the root development from a whole-root graft, which was buried about 5 inches below the surface of the soil. The whitened portion of the root is the original stock. The other roots formed from the scion.

All these experiments go to show that the use of long scions and stocks may be of some little advantage to nurserymen in inducing a better growth of trees during the first two or three years. The long scions and stocks are, however, considerably more expensive than the shorter ones. Planting whole root grafts is much more laborious than planting short piece-root grafts. In reporting these experiments the authors say that the difference in growth in favor of the longer scions and stocks is probably not sufficient to repay the extra expense made necessary by their use.

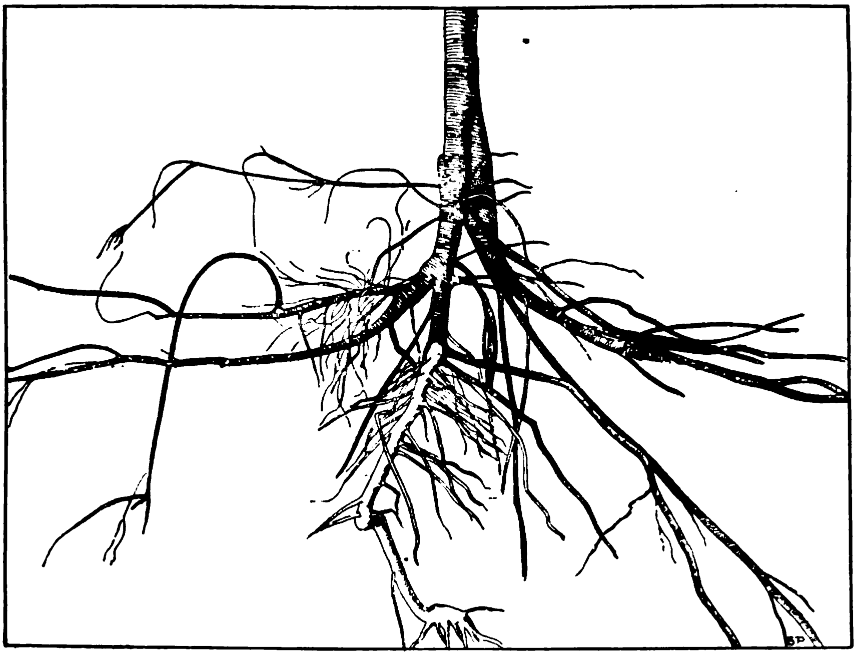

FIG. 2.—Root graft of apples.

For the fruit grower, at least in the locality of the Kansas Station, the longer stocks appear to have no advantage over the shorter ones, since trees produced from them make no greater growth than trees from the shorter stocks except in the first few years. The fact that the greater part of the root growth is made from the upper part of the stocks is evidence that the long stocks serve very little purpose. The production of roots from the scion, as occurred when short piece roots were used, is in many cases a direct advantage, since seedling stocks are very variable in hardiness and vigor of growth. Under the conditions at the Kansas Station piece roots from 2 to 5 inches long are thought to give the best results, all things considered.

FOREST FIRES.

Anyone who has had occasion to travel through the great forest regions of the country is struck with the tremendous losses due to fires. In the northern pineries and the coniferous forests of the far West vast areas have been almost denuded of trees, blackened, charred stumps marking the place where valuable timber once stood. Nor is the loss confined to the destruction of merchantable timber alone. Trees of unmerchantable size and seedlings which, if protected, would have served to replace the timber cut under rational management, are destroyed and the ground is often left bare, to be covered with weeds, grass, and less valuable trees. If upon a mountain side, watershed, or similar exposure, the soil is frequently swept away by the rains which, their natural barriers being removed, sweep down with torrential force.

The causes of forest fires are usually attributed to accident due to sparks from engines, carelessness regarding camp fires, clearing, etc., but not a few, especially in the West, have been due to intentional firing, the object usually being to secure better stock ranges.

The losses occasioned by the destruction of merchantable timber alone amount to millions of dollars each year. Definite figures for the whole country are not obtainable, but the estimated loss due to timber destroyed by forest fires in the State of Pennsylvania is more than $500,000 annually. To this must be added the value of fences and buildings destroyed and other incidental expenses. This is probably a low estimate, but if applied to all the States in the same proportion the sum would appear tremendously large.

We are warned that the consumption of timber in this country under the present system is vastly in excess of the production. Such a state of affairs necessitates some system of forest management. Under any system the question of fires must first receive attention. In 47 States and Territories forestry fire laws have been enacted, but many of them are insufficient, on account of lack of sentiment for their enforcement or from their inadequacy.

One of the greatest sources of danger in lumbering regions is the presence of tops, slashings, and débris. If these are looked after, properly piled and burned, much danger will be avoided. Such a plan is said to have been tried in Canada with success. In the Province of Ontario during 1895 it is said that the feasibility of destroying such waste was clearly established. The protective service was carried on at an expense of about 3¼ cents per 1,000 feet of lumber cut. The expense of burning waste by lumber companies was estimated at $5 per square mile. If these figures are applied to the three great lumber States of Michigan, Wisconsin, and Minnesota, it is claimed that a great part of the annual loss could be prevented at an expense of about $100,000 for each State.

The stations in cooperation with this Department are doing much to disseminate correct ideas about the need and importance of conserving the forest resources of the country. The far-reaching effects upon agriculture, as well as upon other industries, of the destruction of forests make this a question which demands the most serious consideration of every farmer.

AMERICAN CLOVER SEED.

The misrepresentation to which American clover seed has been subjected abroad is well known to all who have investigated the subject. American clover has been reported as greatly inferior in chemical composition to that grown from European seed; it is claimed to be less hardy, and that stock dislike it on account of its great hairiness. By reason of this last characteristic, also, the plants are said to be especially subject to fungus diseases.

In 1897 the exports of clover seed were valued at more than $1,000,000. The introduction of such a large amount of seed into foreign countries tended to lower prices there somewhat, and almost universal condemnation of the American seed followed in the agricultural press of the Continent. This antagonism recently culminated in Austria-Hungary, when a consignment of clover seed, valued at more than $1,600, was excluded and sent back to New York, the explanation being that it contained seed of clover dodder (*Cuscuta epithymum*).

The dodders are well represented in this country. They live parasitically on large numbers of plants, but those known as clover dodders in Europe are not abundant with us. Dodder may be recognized by the yellowish, thread-like, leafless stems which run over and bind together the plants on which it lives. Often it forms such a compact growth that the mass of color is apparent at a considerable distance. The dodder plant is furnished with suckers, which penetrate the plant to which it is attached, robbing the host of its nourishment and causing its death after a time.

The contention that American red clover seed is inferior to European-grown seed and contains dodder seed needs considerable qualification, if it is not wholly erroneous. This can be readily shown from the published reports of the seed control stations of Europe, as well as by the testimony of some of the most prominent agricultural writers of the Continent. At Hamburg specimens of clover seed from Baltimore, Philadelphia, New York, Chicago, Milwaukee, Toledo, and Toronto were examined by an agent whom there is no reason to suppose is favorably disposed toward American seed, and but three samples were found to contain any dodder seed, and that was of a species quite different from the one concerning which complaint is made. Professor Nobbe, of the Tharand Seed Control Station, states that, while American clover seed is not always absolutely dodder-free, yet such is usually the case. He further states that the species of dodder, seed of which are sometimes found in American clover seed, must not be confounded with the clover dodder of Europe, the two being very different.

At the Hohenheim Seed Control Station, in 1895, it was found that out of 480 lots of red clover seed inspected, only 26 of which were of American origin, most of the others having been grown in central Europe, 29.6 per cent contained on an average 200 dodder seeds per pound. Of the alfalfa seed examined 20 per cent contained dodder, and more than 25 per cent of samples of white clover seed were similarly infested.

In the report of the Vienna Seed Control Station for 1890 it is stated that one-fourth of the red clover, one-half of the French, Italian, and Hungarian alfalfa, one-half of the alsike clover, and one-half of the timothy seed contained clover dodder seed. In the report of the same station for 1892 the percentage of samples of seed containing clover dodder were as follows: Red clover 13.3, alfalfa 13.5, alsike 36.2, white clover 14.3, and timothy 12.5. While the origin of all these different lots of seed is not fully stated, it seems probable that American seed supplied but a small proportion of the totals. The existence of the clover dodder in seeds from different parts of Europe is shown by this report, yet it is upon the recommendation of this station that the American seed was excluded.

In reports from the seed control station at Gratz two lots of Austrian seed are specifically reported upon. One of red clover seed from Pettau contained 1.3 per cent clover dodder seed and one of yellow clover seed from Budapest contained 5.2 per cent of the same. These amounts are greatly in excess of any ever reported in American seed, our seed-cleaning machinery eliminating most of the weed seed.

A recent report of one of the Scandinavian seed control stations gives comparative tables showing the relative value of American and European grown seed. From this report it appears that the purity, germinative ability, and viability of the seed in the hands of retail dealers and consumers averaged higher for the American seed. The average percentage of weed seed mixed with the European seed was more than double that found in the American seed.

Investigations carried on at the seed laboratory of this Department show that fully one-fourth of the European seed examined contained varying quantities of dodder seed, while American seed are almost invariably free from these seed.

Comparing the published records of European seed control stations with those of this Department and of the different experiment stations, the evidence shows that American clover seed is, as a rule, of better quality than European seed, and contains very little and often no dodder seed, while about one-fourth of that of European origin does contain it. This comparison shows that there is no just basis for discrimination against American seeds in foreign markets.

MUSHROOMS AS FOOD.

There is a widespread idea that mushrooms and other edible fungi are very nutritious foods. They are commonly said to contain very large quantities of protein (nitrogenous material) and to rank close to meat as sources of this important nutrient. The term "vegetable beefsteak" has been applied to them, and other equally extravagant statements are frequently met with. Numbers of analyses of edible fungi have been reported by the experiment stations. German investigators have also determined their composition and studied their digestibility by human subjects and by methods of artificial digestion.

An extended study of the food value of edible fungi, including their digestibility, has recently been published from the physiological laboratory of the Sheffield Scientific School of Yale University.

Analysis does not show that edible fungi (mushrooms) possess a high food value, as will be seen by the following table, in which their composition is compared with that of several common articles of food:

Comparison of the composition of mushrooms and other foods.

	Water.	Total nitrogen.	Albuminoid nitrogen.	Nonalbuminoid nitrogen.	Protein.	Fat.	Carbohydrates.	Fiber.	Ash.
	Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
Common mushroom (*Agaricus campestris*)	91.30	0.60	0.36	0.24	3.75	0.20	3.50	0.80	0.50
Shaggy coprinus (*Coprinus comatus*)	92.19	.45	.15	.30	2.81	.26	[1]1.40	.57	.98
Inky coprinus (*C. atramentarius*)[2]	92.31	.36	....	....	2.25	.24	....	.72	1.29
Common morel (*Morchella esculenta*)	89.54	.49	.37	.12	3.06	.50	[1]1.60	.91	1.08
Sulphury polyporus (*Polyporus sulphureus*)	70.80	.96	.65	.31	6.00	.93	[1]3.56	.88	2.13
Oyster mushroom (*Pleurotus ostreatus*)	73.70	.63	.30	.33	3.94	.42	[1]4.84	1.97	1.60
Potatoes	75.50	.40	.20	.20	2.50	.10	20.90	.30	1.00
Cabbage	92.50	.18	.11	.07	1.13	.50	.70	....	.70
Carrots	87.50	.18	.08	.10	1.13	10.60		[3]1.50	.80
Wheat bread	35.40	1.52	[3]1.47	[3].06	9.50	1.20	52.80	....	1.10
Beefsteak (round)	63.00	3.00	....	....	18.75	8.80	....	....	1.00

[1] Dextrose. [2] Young small specimens. [3] Approximation.

It will be seen that the mushrooms contain a very high percentage of water. In ordinary food materials protein is the most important nutrient. As regards protein content, the mushrooms rank about the same as potatoes, though they are decidedly inferior in food value, since they contain much less carbohydrates. Nonalbuminoid nitrogen is thought to have little food value. As will be seen, the mushrooms do not contain a high percentage of nitrogen, and a considerable portion of the nitrogen present is in the form of nonalbuminoids.

The value of a food is not determined alone by its composition. The digestibility—that is, the material which the body can retain and utilize—is of even more importance. The experiments at the Sheffield Scientific School showed that from 26 to 59 per cent of the total dry matter of the edible fungi tested was indigestible. The total amount of digestible protein is about the same as in the potato. These results were obtained by the methods of artificial digestion. They agree in all essential points with those obtained by the German investigators. From them the following conclusions were drawn:

When it is remembered that mushrooms contain 75 to 92 per cent of water, and that the total amount of protein present is comparatively small, it will be seen that they correspond with fresh vegetables. Indeed, they are decidedly inferior to many vegetables. The expression "vegetable beefsteak" seems peculiarly inappropriate when applied in a strictly chemical sense. A person depending upon mushrooms to furnish the amount of protein necessary in a day's diet would be compelled to consume about 8 pounds, if the morel, a fair average species, were selected. The carbohydrate content of mushrooms is relatively high, but there is no lack of carbohydrate foods in the ordinary diet, and, consequently, no great need for this constituent of the mushrooms.

Although mushrooms and other edible fungi can not be considered as highly nutritious foods, they are undoubtedly useful condiments or food accessories. They add to the palatability of many food materials when cooked with them, and may be served in many appetizing ways. Their use can undoubtedly be extended by skillful growing and careful marketing. The principal edible fungus raised by market gardeners is the common field agaric (*Agaricus campestris*), and the term mushroom is generally understood to mean this variety.

Although the number of wild edible fungi is comparatively large, there are many poisonous varieties, and too great care can not be exercised in gathering fungi for food. The poisonous and the more important edible fungi have been described in a recent circular of the Division of Botany,[1] and in an earlier publication[2] of this Department a number of native mushrooms were described. The growing and marketing of mushrooms has also been described in a recent bulletin of this Department[3] and a bibliography of mushrooms has been issued by the Department library.[4]

PASTURING PIGS ON STUBBLE FIELDS.

When grain is harvested some necessarily escapes the reaper and is usually lost. While the amount may hardly be sufficient to make it profitable to follow the reaper with a rake, the scattered grain may be profitably utilized by turning pigs or other stock into the stubble fields, and as a matter of fact the custom of pasturing stock on such fields is quite common in many regions.

Some interesting experiments have recently been made at the Montana Station to learn the value of this as compared with other methods of feeding. Forty-one pigs from 6 to 9 months old were allowed the run of barley, wheat, and pea stubble fields of 18, 10.44, and 10.73 acres, respectively. For some time before the test they had been pastured on alfalfa and fed 1 pound of cracked barley per head daily.

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[1] U. S. Dept. Agr., Division of Botany Circular 13.

[2] U. S. Dept. Agr., Division of Microscopy, Food Products, I.

[3] U. S. Dept. Agr., Farmers' Bul. 53.

[4] U. S. Dept. Agr., Library Bul. 20.

For 10 weeks immediately preceding the test they made a daily average gain of 0.42 pound per head. While pastured on the stubble fields they were given no grain in addition to what they could find except on stormy days. The grain thus fed amounted to 24.1 pounds in the 5 weeks of the test.

During this time the pigs made a gain of 22.8 pounds per head, or 17.5 pounds, deducting the amount which it was calculated they gained from the grain fed during stormy weather. On the supposition that 4.5 pounds of grain are required to produce a pound of pork, the 41 pigs gathered 3,228.75 pounds of grain, which otherwise would have been lost. The harvesting had been done in the usual manner, and in the investigator's opinion the amount of peas and grain remaining in the field did not exceed that left in the stubble fields on the average farm. The scattered grain could not have been saved in any other way, and represents a clear profit.

The grain saved from the stubble fields by these pigs was not all that could have been gathered if they had remained in the fields a longer time. Seven brood sows were afterwards pastured during the winter on the station stubble fields, which included a 24-acre oat field in addition to those mentioned above. They were given no food in addition to what they could gather except kitchen slops and a small grain ration on stormy days. The sows frequently rooted down through 6 inches of snow and found sufficient grain to keep them in good condition throughout the entire winter.

It is stated in a recent communication from the Montana Station that several brood sows have been pastured during the past season on stubble fields without receiving any grain in addition, and that they are in fair condition. They had, in addition to the grain stubble fields, the range of clover, alfalfa, and timothy meadows, and the gleanings of fields where root crops had been raised. The manure from grain-fed stock, which was spread upon the fields, also furnished some grain.

ENSILING POTATOES.

A number of French agriculturists have recently studied the desirability of ensiling potatoes. A considerable amount of heat is generated by the fermentation of the green material in silos, and it was thought this could be utilized and the potatoes could be cooked as well as preserved.

In one test the potatoes were buried in a silo filled with crimson clover. They acquired the characteristic color of the plant and the odor developed in fermentation. The tubers were flattened by the heavy pressure to which they had been subjected. When removed from the silo they were comparatively soft. They were examined microscopically and chemically, and it was found that they had been cooked by the heat of fermentation, and that they were rendered more digestible by the process; that is, the percentage of soluble material was increased.

Another silo was filled by surrounding about a ton of potatoes with corn (whole plant). Upon opening, the corn and potatoes were both found in good condition. The tubers were somewhat flattened, as in the previous experiment, but were more cohesive. The potatoes were not as thoroughly cooked, since the temperature and pressure were less than in the previous case.

As shown by analysis, the potatoes ensiled with crimson clover had lost less water than those ensiled with corn. The most striking difference, however, was the high percentage of cooked starch; or, in other words, the increased assimilability of the potatoes ensiled with clover. The crushed potatoes when removed from the silo lost weight very rapidly on exposure to the air, and formed a hard mass containing only 15 to 20 per cent of water. In this condition they could be kept for a long time. When required for feeding purposes they were soaked in water, which they readily absorbed, and thus regained their softness and digestibility.

Another investigator ensiled chopped raw potatoes with 2 pounds of salt per 1,000 pounds of potatoes under pressure of 2,500 pounds per square yard. The total cost of washing, chopping, putting in the silo, and weighting 50 tons of potatoes was about $15. The potatoes were put in the silo in the latter part of November. When the silo was filled the material was 5½ feet deep. Sixty-two days later the silo was opened, and the mass had sunk to a little over 3 feet. The temperature of the silo when filled was 39° F., and when opened it was 50°. The ensiled potato pulp was white, but became blackened on exposure to the air. Cattle ate this pulp greedily, alone or mixed with cotton-seed cake.

Experiments made at the Minnesota Station have shown that while the digestibility of cooked and raw potatoes by pigs was about the same, pigs could be induced to eat larger quantities of cooked potatoes. It was calculated that a ration of 15 pounds of potatoes and 4 pounds of shorts would furnish an amount of protein sufficient for maintenance, leaving a margin for growth.

On the basis of cost comparisons were made of the value of potatoes and other feeding stuffs. In the investigator's opinion, with foods at the present prices, it is doubtful whether it would be profitable to feed large amounts of potatoes to dairy stock, because cows require more protein than would be supplied by a fattening ration similar in character to that mentioned above.

Potatoes can not be fed to young animals as safely as to more mature ones, since if fed in too large quantities they have a tendency to prematurely fatten the animal. With mature animals, when the object is principally the addition of fat to the body, potatoes may be fed to good advantage.

When the crop of potatoes is large and prices low, a method of storing and feeding potatoes to advantage is desirable.

A method of preserving potatoes which at the same time cooks them would seem worthy of trial, but it would doubtless be wise to experiment on a small scale at first.

ANTHRAX.

On account of the rapidity with which it develops and runs its course, the variety of animals subject to it, including man, and its fatality, anthrax, or charbon, is one of the most dreaded diseases to which animals are subject. It is a world-wide disease, and, though few of the experiment stations have been called upon to deal with it, it has been reported during the past decade from Vermont, Massachusetts, Michigan, Connecticut, New York, New Jersey, Pennsylvania, Delaware, Maryland, Mississippi, Louisiana, Texas, Illinois, and South Dakota. The greatest damage seems to have been done in New Jersey and Delaware. In the latter State it has existed since 1892, and of late has infested a territory some 3 miles wide by 40 long along the Delaware River and carried off on an average two animals per farm per year, or from 70 to 82 per cent of the animals in the herds attacked.

Nearly all domestic animals are attacked, including sheep, goats, cattle, horses, mules, swine, and sometimes dogs and cats. Rabbits, guinea pigs, rats, and mice are susceptible to it, and the last two species of domestic pests must be taken into account as transmitters of the disease. In degree of susceptibility sheep stand first and carnivorous animals last. Swine, once thought immune, are very susceptible and readily succumb to it. As a rule domestic animals become infected by the bacilli and spores obtaining entrance to the alimentary tract, and in some cases man becomes infected in the same way by eating improperly cooked meat; but generally human cases of anthrax have been traced to breathing spore-laden air, as in working over wool or hides, and to the infection of cuts, scratches, and other abrasions of the skin.

The spores are very tenacious of life and will remain dormant for years. Cases are recorded where soil has remained infectious for twelve and thirteen years. A moist clay soil seems especially favorable for preserving the germs. As the bacilli are excreted in the urine and feces and in nose and mouth discharges from live animals, and occur in great numbers in the bloody discharges from dead animals, and soon develop spores upon exposure to the air, it may be readily inferred how easily the disease may be spread from place to place. The fact that the disease in Delaware does not seem to have been spread from farm to farm by the infected animal, but to have arisen in all but one case from river drift, and in that one case from sewage from a morocco factory, must be due to lack of opportunity. Anything that can carry the spores may act as a transmitter, and a case has been recorded in which the disease was carried some distance on the clothing and boots of a person who had been aiding at a post-mortem examination. Another case is on record in which a diseased carcass had been buried and the ground above it sown to several crops during as many years, the last crop being clover. The rank growth of the clover excited the cupidity of a neighbor of the person on whose land the clover grew. The clover disappeared, but a day or so after it was missed the neighbor's wife came with the report that her animals were dying. An investigation showed that they had anthrax and also brought to light some of the stolen clover that had not yet been fed. Hay and roots carry the disease as well as grass, but by far the most important factors in the spread of the disease over the world are hides and wool. In the less civilized countries the disease is much more serious than in the United States. In Siberia it has been given the name of the Siberian plague. It is a common disease in South America, whence large numbers of hides are imported. As the hides are simply dried or cured with salt, dung, or clay—processes that in no way affect the vitality of the spores—and as the skinning of an animal must expose large numbers of the bacilli in the blood and in the skin and connected adipose tissues to the air, under the influence of which they quickly transform into the easily scattered spores, the process of handling and packing must infect many more hides than there were animals diseased. When the skins are handled at the tanneries the chances of spreading the disease are thus multiplied many times. Infection has been traced to animals licking the salt from the ground over which salted skins have been carried. The air also is an important medium whenever wool or skins are handled, and anthrax in the lungs and air passages of wool sorters is of such common occurrence as to have given rise to what is termed "wool-sorters' disease." In Delaware, the most important medium for scattering the germs has been the tidal currents of the Delaware River. The progress of various outbreaks of the disease has been studied by the Delaware Experiment Station and found in a number of instances to advance up the river. As no other possible means for spreading the disease could be discovered, and as a study of the currents and tides of the river showed it to be possible for carcasses or germ-laden drift to be carried up the stream, the conclusion was arrived at that the disease must have come from the New Jersey shore. It is explained that when a carcass enters the mouth of a stream, it is carried upward by flood tides. The first ebb tide leaves it stranded on some bar or flat, from which point it will be started by the next flood tide, and with each successive tide the process is repeated until the carcass has become disintegrated and fragments and spores spread over the meadows of the adjacent shores.

Aside from this danger in Delaware from the opposite New Jersey shore there is also danger from sources up the river. Nearly four-fifths of the output of morocco in the United States is produced in the cities of Philadelphia and Wilmington. The daily product exceeds $80,000 in value. The skins are received from India, Russia, Africa, China, Australia, and South America. In all of these countries anthrax outbreaks are common and rage without control. It follows that the washing from the twenty-five Philadelphia shops and the fourteen shops in Wilmington carry myriads of spores to the river.

To be added to this list of disease bearers are fleas, mosquitoes, and flies. From a specimen of the first of these insects taken from animals infected with anthrax the bacilli have been isolated, and the report of the Delaware Station records cases where the only possible explanation for the existence of the disease is that it was carried by flies from anthrax carrion.

EXPLANATION OF TERMS.

TERMS USED IN DISCUSSING FERTILIZERS.

Complete fertilizer is one which contains the three essential fertilizing constituents, i. e., nitrogen, phosphoric acid, and potash.

Nitrogen exists in fertilizers in three distinct forms, viz, as organic matter, as ammonia, and as nitrates. It is the most expensive fertilizing ingredient.

Nitrates furnish the most readily available forms of nitrogen. The most common are nitrate of soda and nitrate of potash (saltpeter).

Phosphoric acid, one of the essential fertilizing ingredients, is derived from materials called phosphates. It does not exist alone, but in combination, most commonly as phosphate of lime in the form of bones, rock phosphate, and phosphatic slag. Phosphoric acid occurs in fertilizers in three forms—soluble, reverted, and insoluble phosphoric acid.

Soluble phosphoric acid is that form which is soluble in water and readily taken up by plants.

Reverted phosphoric acid is that form which is insoluble in water but still readily used by plants.

Available phosphoric acid is the soluble and reverted taken together.

Superphosphate.—In natural or untreated phosphates the phosphoric acid is insoluble in water and not readily available to plants. Superphosphate is prepared from these by grinding and treating with sulphuric acid, which makes the phosphoric acid more available to plants. Superphosphates are sometimes called acid phosphates.

Potash, as a constituent of fertilizers, exists in a number of forms, but chiefly as chlorid or muriate and as sulphate. All forms are freely soluble in water and are believed to be nearly, if not quite, equally available, but it has been found that the chlorids may injuriously affect the quality of tobacco, potatoes, and certain other crops. The chief sources of potash are the potash salts from Stassfurt, Germany—kainit, sylvinit, muriate of potash, sulphate of potash, and sulphate of potash and magnesia. Wood ashes and cotton-hull ashes are also sources of potash.

TERMS USED IN DISCUSSING FOODS AND FEEDING STUFFS.

Water is contained in all foods and feeding stuffs. The amount varies from 8 to 15 pounds per 100 pounds of such dry materials as hay, straw, or grain to 80 pounds in silage and 90 pounds in some roots.

Dry matter is the portion remaining after removing or excluding the water.

Ash is what is left when the combustible part of a feeding stuff is burned away. It consists chiefly of lime, magnesia, potash, soda, iron, chlorin, and carbonic, sulphuric, and phosphoric acids, and is used largely in making bones. Part of the ash constituents of the food is stored up in the animal's body; the rest is voided in the urine and manure.

Protein (nitrogenous matter) is the name of a group of substances containing nitrogen. Protein furnishes the materials for the lean flesh, blood, skin, muscles, tendons, nerves, hair, horns, wool, casein of milk, albumen of eggs, etc., and is one of the most important constituents of feeding stuffs.

Albuminoid nitrogen is nitrogen in the form of **albuminoids**, which is the name given to one of the most important groups of substances classed together under the general term protein. The albumen of eggs is a type of albuminoids.

Amid nitrogen is nitrogen in the form of **amids**, one of the groups of substances classed together under the general term protein. Amids, unlike albuminoids, are usually soluble in water, but are generally considered of less value as food than albuminoids.

Carbohydrates.—The nitrogen-free extract and fiber are often classed together under the name of carbohydrates. The carbohydrates form the largest part of all vegetable foods. They are either stored up as fat or burned in the body to produce heat and energy. The most common and important carbohydrates are sugar and starch.

Fiber, sometimes called crude cellulose, is the framework of plants, and is, as a rule, the most indigestible constituent of feeding stuffs. The coarse fodders, such as hay and straw, contain a much larger proportion of fiber than the grains, oil cakes, etc.

Nitrogen-free extract includes starch, sugar, gums, and the like, and forms an important part of all feeding stuffs, but especially of most grains.

Fat, or the materials dissolved from a feeding stuff by ether, is a substance of mixed character, and may include, besides real fats, wax, the green coloring matter of plants, etc. The fat of food is either stored up in the body as fat or burned, to furnish heat and energy.

MISCELLANEOUS TERMS.

Fungus (plural **fungi**) is a low form of plant life destitute of green coloring matter; mold and mushrooms are familiar examples.

Spore is a minute body, borne by a fungus, which is capable of reproducing the fungus directly. It corresponds in function with the seed of higher plants.

Bacillus (plural **bacilli**) is a genus of **bacteria**, which is the name applied in common to a number of different or closely related microscopic organisms, all of which consist of single short cylindrical or elliptical cells or two such cells joined end to end and capable of spontaneous movement. Many kinds of bacteria are harmful and cause diseases and other injurious effects, but many are beneficial. Among the latter are those which give aroma to tobacco and flavor to butter and cheese, and those which enable leguminous plants to use the free nitrogen of the air.

Inoculation is the introduction of bacteria or other organisms into surroundings suited to their growth with a view to producing the effects which are the result of their activity.

FARMERS' BULLETINS.

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74. Milk as Food. Pp. 39.
75. The Grain Smuts. Pp. 20.
76. Tomato Growing. Pp. 30.
77. The Liming of Soils. Pp. 19.
78. Experiment Station Work—V. Pp. 32.
79. Experiment Station Work—VI. Pp. 28.
80. The Peach Twig-borer. Pp. 16.
81. Corn Culture in the South. Pp. 24.
82. The Culture of Tobacco. Pp. 24.
83. Tobacco Soils. Pp. 23.
84. Experiment Station Work—VII. Pp. 32.
85. Fish as Food. Pp. 30.
86. Thirty Poisonous Plants. Pp. 32.
87. Experiment Station Work—VIII. Pp. 32.
88. Alkali Lands. Pp. 23.
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107. Experiment Station Work—XIII. Pp. 32
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112. Bread and Bread Making. Pp. 39.
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114. Experiment Station Work—XIV. Pp. 28.
115. Hop Culture in California. Pp. 27.
116. Irrigation in Fruit Growing. Pp. 48.
117. Sheep, Hogs, and Horses in the Northwest. Pp. 28.
118. Grape Growing in the South. Pp. 32.
119. Experiment Station Work—XV. Pp. 31.
120. The Principal Insects Affecting the Tobacco Plant. Pp. 32.
121. Beans, Peas, and other Legumes as Food. Pp. 32.
122. Experiment Station Work—XVI. Pp. 32.
123. Red Clover Seed. Pp. 11.
124. Experiment Station Work—XVII.
125. Protection of Food Products from Injurious Temperature. Pp. 26.

U. S. DEPARTMENT OF AGRICULTURE.

FARMERS' BULLETIN No. 80.

THE PEACH TWIG-BORER:

AN IMPORTANT ENEMY OF STONE FRUITS.

BY

C. L. MARLATT, M. S.,
First Assistant Entomologist.

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1898.

LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
DIVISION OF ENTOMOLOGY,
Washington, D. C., June 15, 1898.

SIR: I have the honor to transmit herewith a Farmers' Bulletin on the peach twig-borer, an important enemy of stone fruits. It has been prepared by my first assistant, Mr. C. L. Marlatt, and consists in the main of a revision of an article published in Bulletin No. 10, new series, of this Division. It is issued in its present form to supply a demand for a larger circulation of the information contained in the article cited, particularly in California and elsewhere on the Pacific slope, where the twig-borer is especially abundant and destructive.

Respectfully,

L. O. HOWARD, *Entomologist.*

Hon. JAMES WILSON,
Secretary of Agriculture.

CONTENTS.

Page.
Introduction 3
Recent studies of the insect 3
History and distribution 5
Life history and habits 6
The strawberry crown-miner a distinct insect 11
Natural parasites 12
Remedies and preventives 12
Winter treatment with kerosene emulsion 13
Spring or fall treatment with arsenicals 14

ILLUSTRATIONS.

FIG. 1. ***Anarsia lineatella,* showing the newly-hatched larva and its hibernating chambers in the crotches of trees 6**
2. *Anarsia lineatella,* showing work of overwintered larva on peach shoot, and also enlarged figures of full-grown larva and pupa 7
3. *Anarsia lineatella,* showing moth with spread wings, and two views of the moth showing the ordinary resting position 9
4. *Anarsia lineatella,* showing egg and newly-hatched larva 9
5. *Pediculoides ventricosus,* an efficient mite parasite of the hibernating larvæ 12

THE PEACH TWIG-BORER.

(*Anarsia lineatella* Zell.)

INTRODUCTION.

This insect is of European origin, but has been known to occur in the United States since 1860. It has been very injurious at times to peach trees in the peach-growing sections of the East, notably in Maryland, Delaware, and Virginia, also in New Jersey and New York, and more recently in West Virginia. In California and Oregon, and elsewhere on the Pacific slope, its injuries have taken a wider range, including damage to the apricot, almond, nectarine, prune, pear, and perhaps other fruit trees in addition to the peach.

In California it is listed as one of the three or four worst insect pests occurring in the State. In Washington as many as one hundred larvæ, or instances of damage to as many twigs, have been counted on a single tree. In Oregon this insect is stated to be next to the peach-tree borer in the amount of damage it occasions, particularly in the Willamette Valley. In western Colorado it is very destructive to peach, plum, apricot, and almond.

The injury occasioned by this insect is limited almost exclusively to the work of the hibernating larvæ during the latter part of April and first of May, when they bore into the shoots of new leaves, killing the growing terminals and preventing the development of the branch, although sometimes a whorl of living leaves may remain at the base. Much of the new growth of the tree is often killed, in many instances the branches remaining with scarcely a bud or shoot which has not been thus destroyed. This necessarily results in greatly checking the vigor and fruiting capacity of the tree, and causes an irregular and knotty growth.

The summer broods of larvæ feed beneath the bark or in the fruit stems, occasionally, when nearly full grown, boring into the fruit; but such damage is not ordinarily noticed and is slight as compared with the injury occasioned by the first or hibernating brood of larvæ.

RECENT STUDIES OF THE INSECT.

Up to comparatively recent years the knowledge of this insect has been practically confined to its injury to peach twigs, either in terminals before the trees leaf out in the spring, a rare form of attack, or in the young shoots—the usual and destructive habit—and later and more rarely in the ripening fruit. In connection with these descriptions of damage are also accounts of what was then believed to be the same insect affecting the strawberry, one brood wintering in the half-grown larval stage in the crown of the plant, and a second brood working during early summer in the young shoots and runners.

The confusion of these two distinct species, attacking widely dissimilar plants, continued until 1897, and still obtains to a great extent. There necessarily resulted a thorough misapprehension of the habits of the twig-borer and the suggestion of needless precautionary measures, such as the abandonment of the culture of the strawberry, at least in proximity to peach orchards.

In 1893 some very interesting observations were made by Mr. Ehrhorn, in Santa Clara County, Cal., and reported by Mr. Craw, demonstrating that the twig-borer winters, in the larval stage, not in the crown of the strawberry plant, as had been previously thought, but in peculiar chambers situated for the most part in the crotches of the branches of the trees attacked, the larvæ leaving these chambers in the spring to do the notable damage characteristic of the species.

While passing through California in the fall of 1896, the writer examined, in company with Mr. Ehrhorn, the curious hibernating chambers made by the newly-hatched larvæ, and the habits of this insect, as far as then known to Mr. Ehrhorn, and substantially as had been already recorded by Mr. Craw, were explained to him. The discovery of this peculiar hibernating habit of *Anarsia lineatella* is very interesting in itself, and is also a long step toward the completion of our knowledge of the life history of the insect, and is especially valuable as suggesting better means than any heretofore known of preventing damage from it.

Arrangements were made with Mr. Ehrhorn at the time to supply the Department with ample material of the young larvæ in their hibernating cells; and, throughout the winter, spring, and early summer of 1896–97, material was repeatedly sent for study to Washington, D. C.

Some of the twigs containing the young hibernating larvæ were during the winter fastened to peach trees growing in the entomological nursery attached to the insectary. Most of the larvæ in these twigs had been killed by a predaceous mite, and some few, perhaps, died as a consequence of the drying up of the twigs, but a considerable number of them wintered safely and ultimately entered the new shoots in the early spring and completed their development. With this material we were enabled to study their habits out of doors under natural conditions, following the species carefully through two generations and into the commencement of a third, as will be detailed below. By the end of August our working stock died out and we were unable to secure fresh supplies. The studies made in Washington were supplemented and confirmed by the field observation of Mr. Ehrhorn covering the same period and continuing until the hibernating cells reappeared in the crotches in August and September.

About the same time Mr. A. B. Cordley, entomologist of the Oregon Experiment Station, was also investigating the habits of this insect, his account comprising a description of the injury to peach and prune twigs in early summer, and the work of similar larvæ in strawberry beds in October, the latter larvæ wintering in the crowns of the plants.

HISTORY AND DISTRIBUTION.

The peach twig-borer is apparently an Old World species and probably a very ancient enemy of the peach, with little doubt coming with this fruit from western Asia. It was described in Europe in 1839, and in this country in 1860. The American species was afterwards shown to be identical with the European peach moth. As an important injurious insect in this country, attention was first drawn to it about 1872 by Mr. Glover, a former entomologist of the Department, and also by Mr. Saunders, of Ottawa, the report of Mr. Glover being the first published. Glover's report describes excessive damage by it as a twig-borer in young peach orchards in Maryland, and Saunders's report, while relating chiefly to marked injury by a crown-borer in strawberry beds (now known to be a different insect), refers also to injury to the peach twigs in Ontario. Some years later, Prof. J. H. Comstock, while entomologist of the Department, reported considerable damage from the peach twig-borer in Virginia and in the District of Columbia, and first noted the peculiar fruit-inhabiting brood. Later the insect was made the subject of an article by Dr. J. A. Lintner, in which it is reported to have occasioned damage to peaches in several localities in the State of New York. We also have accounts by Prof. C. V. Riley, of injury to strawberry plants in Illinois, referred by him to *Anarsia lineatella*, and also articles on this insect, particularly as a strawberry miner, by Prof. S. A. Forbes. Very great damage to peaches in Kent and Sussex counties, Del., was reported later by Riley and Howard.

On the Pacific slope record was made of injury by it to various stone fruits by Mr. Coquillett, and later similar damage was reported from Vancouver. We have also the results of the investigations by Mr. Ehrhorn in California, and the recently published accounts by Mr. Cordley relative to the insect as affecting peaches and prunes in Oregon, and also in strawberry beds—a similar but undoubtedly distinct insect.

That this twig-borer is very destructive to the peach, plum, apricot, and almond in western Colorado is shown by recent accounts, and damage from it has also been lately reported in West Virginia.

In addition to the more important published accounts, injury from the twig-borer has been often recognized and reported by various observers in recent years. Nearly all these reports refer to the injury to twigs of stone fruits, and very few to the strawberry, the allied insect which infests the latter either being more rare or less often observed. The records of this Department show the presence of the twig-borer in at least twelve States, and give it a range which indicates that it is practically as wide-spread in this country as is the culture of its principal food plant.

If not already cosmopolitan in distribution, the peach twig-borer is rapidly becoming so, and will probably follow the peach and other stone fruits wherever they are cultivated, especially as its peculiar hibernating habit greatly facilitates its distribution with nursery stock.

LIFE HISTORY AND HABITS.

The fall brood of larvæ discovered by Mr. Ehrhorn may be taken as a convenient starting point in the life history of the peach twig-borer. In the fall, according to Mr. Ehrhorn, they appear as very small larvæ, living and working in the spongy bark chiefly at the crotches of the branches of the peach, and he surmises that they are from eggs deposited in these situations. Here the larvæ are supposed to grow slowly until the new growth appears in the spring, when they leave their cells in the bark and enter the new shoots. It is stated, also, that frequently the larvæ are nearly full grown when they attack the young growth. A later brood is said to attack the fruit near the stems. The occurrence of the larvæ during the winter in the situations described is also thought to explain the fact frequently noted that the under and inside twigs, being the more accessible, suffer the most, while the exterior and topmost branches escape.

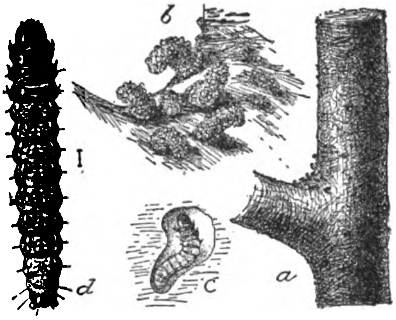

FIG. 1.—*Anarsia lineatella:* *a*, twig of peach, showing in crotch minute masses of chewed bark above larval chambers; *b*, latter much enlarged; *c*, a larval cell, with contained larva, much enlarged; *d*, dorsal view of young larva, more enlarged (original).

Later studies confirm, in the main, Mr. Ehrhorn's conclusions as to the habits of the larvæ. That the larvæ make any essential growth in the winter, however, is probably a wrong inference, as will be shown later, and the nearly full-grown larvæ referred to were doubtless individuals that were wandering from one point to another, and had merely reached nearly full growth before they were observed.

Both in the orchards of California and by means of the abundant material received at this office we have been enabled to make a careful study of the hibernating galleries, or chambers, of the young larvæ. These occur not only in the crotches of the smaller and sometimes quite large branches, but many of the larvæ utilize the roughened bark at any point. They burrow into the bark for a short distance, penetrating little more than the upper superficial layer, and form slightly elongated chambers (fig. 1, *c*), which are lined with white silk and the opening afterwards closed. The location of the larvæ may be readily recognized by the little masses of projecting excrement or comminuted bark at the entrances to the burrows (fig. 1, *a*, *b*). The size of the burrow and the fact of its being lined with silk precludes the idea that the larva feeds in the fall or during hibernation, except perhaps in the mere operation of excavating the chamber.

The young larva, as taken from the burrow, is not above 2 millimeters long, and is of a general yellow color, with the head and cervical and anal plates dark brown, almost black (fig. 1, *d*).

While in their winter quarters the larvæ are subject to the attacks of predaceous mites, and many of them are destroyed by this means, as will be later noted. They are also occasionally parasitized by a chalcidid fly.

Early in April the larvæ begin to abandon their hibernating quarters and attack the new leaf shoots, but some individuals were found in the crotches by Mr. Ehrhorn as late as April 21. The damage becomes noticeable, as a rule, at the time the shoots are from one-half inch to 2 inches in length, or, more properly speaking, mere clusters of newly expanded leaves.

Glover's account of their working downward in the old twigs from the terminal buds before the starting of the leaves in April apparently can not be questioned, but seems not to be the normal course, as shown by the observations since made.

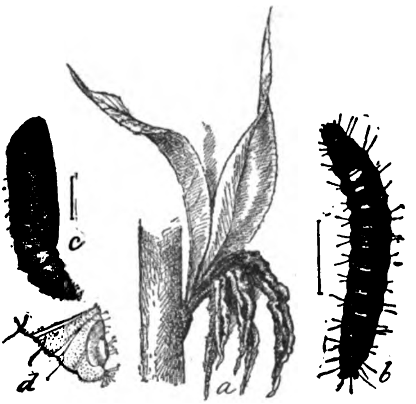

FIG. 2.—*Anarsia lineatella*: *a*, new shoot of peach withering from attack of larva; *b*, larva enlarged; *c*, pupa enlarged; *d*, tip of pupa more enlarged (original).

In our experience, the larvæ begin to migrate only after the new foliage has begun to put out, and they attack the new shoots at any point, generally, however, from one-half inch to an inch from the apex, either near or in the crotch formed by the leaf petiole and the stem. The longest burrow observed was 1½ inches and the shortest one-fourth inch. Sometimes the burrow extends about one-eighth inch above the entrance, and occasionally the larvæ simply eat into the shoot as far as the pith and then go elsewhere. The larvæ are seemingly restless and not easily satisfied, and are continually moving from one shoot to another, and are most active travelers. In this way a single larva may destroy or injure several shoots before reaching maturity, thus greatly increasing the damage.

Professor Comstock's observations on the habits of the larvæ in the young shoots are slightly at variance with the above. He says the larvæ puncture the shoots at the base, eating them off completely, the severed twigs remaining attached to the branch by the gummy substance which exudes from the wound. This particular form of injury we have not noted.

When working in the succulent new growth the larvæ bores rather rapidly, sufficiently so at least to excavate a burrow two-thirds of its length in an hour. The length of time spent by the hibernated larvæ in coming to full growth in the green shoots is comparatively short, not exceeding ten to fifteen days.

In California, and also in the District of Columbia, the larvæ begin transforming to pupæ in the latter part of April, and the moths of the first brood emerge throughout May. In Colorado, Mr. Gillette has bred the moths the first of June and also toward the end of July. In Oregon, Mr. Cordley secured his first pupa on May 8 and his first moth on May 17.

The adult larva tapers strongly toward either end, and attains a length of three-eighths to a half an inch, or slightly more when in motion. It is of a dull reddish-brown color, the reddish color predominating before maturity and the latter after maturity, and the head and the cervical and anal shields are dark brown or almost black. The space between the segments is noticeably light-colored, and especially between the second and third thoracic segments. The hairs are long and spring singly from minute tubercles. Other details of structural features are shown in the illustration (fig. 2, *b*).

In confinement the larva on reaching full growth spins a scanty web, in no sense a close cocoon, in the leaves and rubbish about the trees, or on the trees in the dried and shriveled leaves of the injured shoots, or it attaches itself exposed on the twigs or bark. After thus securing itself the larva immediately pupates, becoming a brown, rather robust, chrysalis (fig. 2, *c*, *d*). In midsummer these transformations are very quickly accomplished. A larva, for example, which webbed up June 29, pupated July 1, and the adult emerged July 8.

Mr. Ehrhorn states that it is very difficult to find the pupæ in orchards, as the larvæ hide in all sorts of places, as in crotches of the branches, between dried leaves, and about small peaches likely to drop off.

The chrysalis stage lasts from seven to ten days, and the moths of the first brood begin to appear early in May and continue to emerge throughout this month and into June in the latitude of Washington.

The adult moth is less than a quarter of an inch in length, expanding a little more than half an inch, and is of a beautiful dark-gray color, with darker spots on the forewings, as indicated in the illustration (fig. 3). It is a handsome insect, and has a peculiar way of resting with its palpi bent back over its head and its antennæ laid closely down on the wings.

The actions of the moths out of doors have been recently described by Mr. Cordley. During the daytime they remain perfectly still on the bark of the tree, and with the forepart of the body slightly raised and the labial palpi held rigidly upright in front of the face. They so closely resemble small, rough projections of the bark that it is almost impossible to distinguish them. When disturbed they dart rapidly about for an instant and then as suddenly alight in a new position.

The egg-laying habits of this insect previous to 1897 having been merely a matter of conjecture, special effort was made to get the facts concerning this feature of the life history. A number of moths reared in the insectary were confined about May 10 with peach twigs 8 to 10 inches in length, of this year's growth. The examination of the material was unfortunately too long delayed, but on May 28 it was found that many eggs had been deposited on these peach twigs, an egg having been placed apparently just above the base of the petiole of nearly every leaf. When examined, most of the eggs had hatched and the larvæ had entered the twigs at or near the crotch formed by the leaf and twig, the point of entrance being indicated by a little mass of brown excrement.

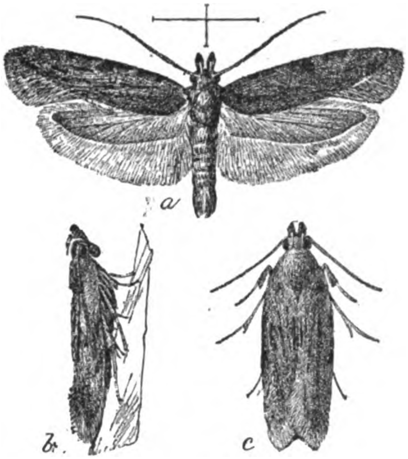

FIG. 3.—*Anarsia lineatella*: *a*, moth with spread wings; *b* and *c*, same with wings closed, illustrating position normally assumed—all much enlarged (original).

The egg had evidently been placed in the protection formed by by the two little spurs at the base of the petiole. Subsequently many other eggs were obtained from other moths, and they were, for the most part, similarly situated, namely, around the base of the leaves. In one instance nine eggs were deposited around the base of a single leaf, six of them close together under one of the bracts at the base of the petiole and three in the depression or scar left by the second bract, which had dropped.

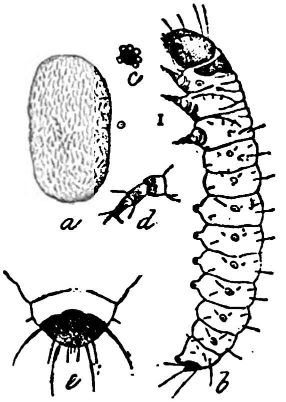

FIG. 4.—*Anarsia lineatella*; *a*, egg; *b*, young larva; *c*, eye; *d*, thoracic leg of larva; *e*, anal segment from above—all greatly enlarged (original).

The recently deposited eggs are white in color and iridescent, but before hatching become distinctly orange. They measure about four-tenths of a millimeter in length by two-tenths of a millimeter in breadth, are somewhat ovoid, and are lightly attached lengthwise to the twig by a glue-like material. Under a high power they are seen to be coarsely and rather regularly reticulated, as shown in the illustration (fig. 4, *a*).

In confinement the moths live about ten days, and most of the egg-laying is in the first half of this period. The habits above described are those of caged moths, but it is reasonable to suppose that in a state of nature the eggs are deposited in much the same way, and this is rendered almost certain by the great regularity noted in the manner of their deposition. In but one or two instances were the eggs placed in other situations—one being placed on the upper surface of a leaf close to the midrib, and two together placed in a groove at the side of the base of the leaf.

From eggs deposited later than those first mentioned, viz, about June 3, larvæ appeared June 15, indicating a period of about twelve days between the laying of the egg and its hatching.

The newly hatched larvæ measure about 1 millimeter in length and are of a very pale yellow color, with the head and cervical and anal plates black and the thoracic legs dusky. When first noted they had excavated channels somewhat longer than themselves and about twice as broad into the twigs, the entrance being marked by a small mass of excrement. By June 3 most of the older larvæ had abandoned their original burrows and were constructing new ones in similar situations on fresh branches of the peach, with which they were from time to time supplied. This they continued to do, viz, to construct new burrows every few days until they were full grown. On June 23, of the three remaining individuals of this lot of larvæ, one had already pupated in a folded leaf and the other two were fully grown and about ready to transform, which they both did before the end of the month.

About the end of June some peaches were received from Mr. Ehrhorn, said to be infested with the second brood of larvæ. Some of the peaches had been bored into a little way near the stem by what was evidently, from the size and nature of the burrows, nearly full-grown larvæ of the second brood. One of these was found, and also one pupa. On further examination, however, it was discovered that the larvæ of what is undoubtedly the third brood (the second of the summer broods) were present in numbers, not in the fruit, but in the short stems of the fruit, which at this season are green and somewhat succulent. In these stems they had made their little chambers not unlike those in the twigs above described or those in the crotches in the fall, except that they were for feeding purposes and not lined with silk, as are the latter. Others were also found at the base of the leaf stalks, just as we had been finding them in our breeding cages.

We were unable to carry our breeding-cage material farther than this point at Washington, D. C., and Mr. Ehrhorn was unable to furnish additional supplies, but he writes that he found the minute larvæ in the crotches of the trees as early as August 21. It would seem from this last and very important observation that some, at least, of the fourth brood of larvæ, if not all of them, go into winter quarters, and at a period much earlier than would have been supposed.

These facts go a long way toward clearing up the life history of this insect, and indicate a much more uniform habit in the different broods than has hitherto been supposed.

The old idea that this insect is double-brooded, the first brood living in the twigs and the second brood affecting the ripening fruit, must be abandoned. At the time of the appearance of the first brood of moths during the month of May the fruit of the peach is of considerable size, especially by the end of the month, but is green, hard, and densely hairy, and is probably rarely if ever chosen by the parent moths as a nidus for her eggs. The normal location of the eggs and the point at which larval development begins is indicated by the foregoing notes, and there is no reason to doubt but that at all seasons of the year larvæ develop in the new growth, entering normally at the axils of the leaves or in the stems of the green fruit. In these situations the eggs are placed and the young larvæ construct their little oval chambers, which they abandon from time to time to make new ones, rarely doing enough damage in the later broods at any one point to be noticeable. As they attain larger size they travel more and often bore into fruit near the stem, where the greater exudation of gum and more serious character of the injury draw attention to them. In the case of the burrows in the twigs the more abundant new growth and more mature condition of the wood render the injury much less noticeable, nor are the results of the attacks so marked as in the injury to the new growth in April.

Our records for the first summer brood indicate a period of about six weeks as necessary for its complete development. The time necessary in the warmer months for the later broods is probably even less, and it is evident that there are certainly three broods of larvæ annually, if not four.

One of the important points remaining to be cleared up in regard to this insect is whether the larvæ found in the crotches of the branches in late summer and fall come from eggs placed in these situations or are migrants from some other parts of the plant. Mr. Ehrhorn's supposition that the eggs were placed by the moth where the larval chambers are afterwards found is borne out by the small size of the larvæ, which are not much larger than when newly hatched. The comparatively large size of the egg, and its striking appearance, and the lack of any attempt at concealment of it should enable one, where the insect is abundant, to clear up this uncertain feature without difficulty.

THE STRAWBERRY CROWN-MINER A DISTINCT INSECT.

The generally held belief hitherto that the lepidopterous crown-miner of the strawberry is the same insect as the twig-borer of the peach will have to be abandoned. If there were no other evidence on which to base this conclusion, the habits of the twig-borer, as now known, throughout the year are so peculiar and distinctive as to render very improbable the supposed strawberry infesting habit.

That we have two distinct insects is also convincingly shown by a comparative study of the larvæ from the strawberry and from the twigs of stone fruits, obtained from various parts of the country, made in connection with an examination of the published descriptions of larvæ and their habits from both sources. So dissimilar are the larvæ that there is no basis whatever for connecting them with the same insect, and in fact they probably belong to different families.

The moths of the strawberry crown-miner, on the other hand, are very similar in appearance to the moths of the twig-borer, as dry, mounted objects. The habits of the living insects, however, of the two species are, on the authority of Mr. Cordley, very dissimilar. The twig-borer moths are slightly larger and darker colored than the strawberry insect, and invariably take an elevated position in the breeding cage with the fore part of the body slightly raised and the labial palpi held rigidly upright in front of the face, as elsewhere noted. The moths reared from the strawberry crowns, on the other hand, crawl down among the vines, even into crevices in the soil, apparently for the purpose of depositing eggs upon the crowns of the plants, and when disturbed run or flutter about with wings half spread.

This strawberry insect seems undescribed although its larval habits are fairly well known. The important consideration, at any rate, is established that the culture of the strawberry presents no menace to the grower of stone fruits, since the damage under discussion to the two plants has no connection.

NATURAL PARASITES.

That the larvæ of the peach twig-borer are attacked by parasites during the hibernating period has already been alluded to, and in fact, of the material received from Mr. Ehrhorn, nearly all had been destroyed by a minute predaceous mite, *Pediculoides ventricosus* (fig. 5). In most instances nothing remained of the larvæ except the empty heads.

Two minute hymenoptera, or four-winged fly parasites, have also been reared from the larvæ. The first of these was obtained by Professor Comstock, who in his studies of the peach twig-borer reared a parasite from it which he did not name, but which was later described by Dr. L. O. Howard as *Copidosoma variegatum*. The second fly parasite of Anarsia was obtained from the material in tree crotches submitted by Mr. Ehrhorn, and proves to be *Oxymorpha livida* Ashmead, a wide-spread species quite variable in point of size.

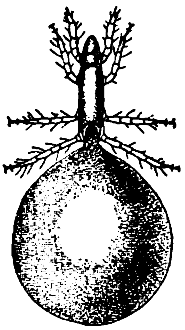

FIG. 5. — *Pediculoides ventricosus* — much enlarged (original).

Of these parasites, in California the greatest benefit is derived from the mite, which, as we have already stated, frequently causes the death of from 75 to 95 per cent of the young larvæ.

REMEDIES AND PREVENTIVES.

The common method of procedure against this insect, and the one hitherto generally suggested, is to clip off and burn the withering infested tips in the spring as soon as the injury is noted. The foregoing life history emphasizes the fact that it is necessary to do this very promptly, for the larvæ remain in these situations a very short time, and early in May will have abandoned their burrows in the young shoots to transform, often elsewhere, although sometimes pupating in the withered leaves. The presence of dying terminals does not always indicate that a larva is necessarily present, since in many instances it will have wandered to some other point. With large orchards this step would be a very tedious one, and with trees of any size often impracticable.

WINTER TREATMENT WITH KEROSENE EMULSION.

The knowledge of the hibernating habits of this insect indicates a more effective method of control. This consists in spraying the trees during December or January, or any time after the foliage has fallen, with kerosene emulsion, resin wash, or some similar oily preparation which will penetrate the burrows and destroy the young larvæ. Mr. Ehrhorn found the kerosene treatment very satisfactory, as practiced in California in the winter of 1897–98, the little excremental pellets of the larvæ absorbing the oily mixture and leading it directly to the insect in its hibernating cell. For California Mr. Ehrhorn recommends that the application of the mixture should be begun in December.

Kerosene emulsion has one advantage over other oily preparations, such as the resin wash, in that it is more penetrating and will be more certain of reaching the larvæ.

Where the emulsion is to be prepared by hand it is better to make it in rather small quantities at a time in order to secure a perfect combination of oil and soap. The proportions usually taken are as follows: Kerosene, 2 gallons; whale-oil soap, half a pound; water, 1 gallon.

The soap, first finely divided, is dissolved in the water by boiling and immediately added boiling hot, away from the fire, to the kerosene. The whole mixture is then agitated violently while hot by being pumped back upon itself with a force pump and direct discharge nozzle, throwing a strong stream, preferably one-eighth inch in diameter. After from three to five minutes' pumping the emulsion should be perfect, and the mixture will have increased from one-third to one-half in bulk and assumed the consistency of cream. Well made, the emulsion will keep indefinitely, and should be diluted only as wanted for use.

For the treatment of large orchards, requiring large quantities of the emulsion, it may be advisable to prepare it with the aid of a steam or gasoline engine and suitable large tanks, as has been very successfully and economically done in several instances, all the work of heating, churning, etc., being accomplished by this means. When thus made the following proportions may be suggested: Kerosene, 10 gallons; whale-oil soap, 2½ pounds; water, 5 gallons. As a winter wash the emulsion may be diluted with about six volumes of water, making for the larger quantity about 100 gallons and the smaller about 20 gallons of spraying mixture.

When hard water is employed in the making of the emulsion or in diluting afterwards, it is necessary to use about 25 per cent more soap, or preferably the water may be broken with lye, or rain water may be used.

In the use of kerosene or other oily washes on plants, the application should be merely sufficient to wet the plant without causing the liquid to run down the trunk and collect about the crown; usually at this situation there is a cavity caused by the swaying of the plant in the wind, and the accumulation of the insecticide at this point may result in the death or injury of the plant. It is even advisable to mound up the trees before spraying or to see that the earth is firmly packed about the base. Care should also be taken in refilling the tank to see that no free oil is allowed to accumulate in the residue left at the bottom.

In line with the use of kerosene emulsion may be suggested the use of pure kerosene mechanically combined with water in the act of spraying, as is now effected by a style of pump specially made for the purpose. A 20 to 25 per cent solution of the kerosene can be used without danger to the plant in its dormant condition, but it is necessary to watch the apparatus employed for this work very carefully to see that the proportion of oil to the water does not change, and on the whole it is much safer and more satisfactory to use the kerosene emulsion, the strength of which may be known definitely in advance and is not subject to variation.

SPRING OR FALL TREATMENT WITH ARSENICALS.

The possibility of destroying the larvæ of the peach twig-borer by spraying the plants with arsenicals, either in the fall or spring, has also been suggested, but such treatment demands the greatest caution on account of the extreme sensitiveness of the foliage of the trees ordinarily attacked by this insect to scalding when sprayed with these poisons.

The fall treatment is directed against the last brood of larvæ, and to be effective the poison should reach the parts of the plant where the eggs are most apt to be placed, presumably the crotches of the branches. Many of the larvæ might thus be poisoned while eating through the bark preliminary to the construction of their winter retreats. To effect anything of value by this course the poison must be applied early—that is, before the eggs are deposited—and the feasibility of the treatment will depend somewhat on the condition of the trees and the damage that might result from scalding of the foliage in late summer.

As a spring treatment, the arsenical spray should be applied to the trees at the moment the leaf-buds begin unfolding, so that the first meal taken by the over-wintered larvæ will be a poisonous one. The difficulty with this method is that already given—namely, the extreme sensitiveness of the foliage of the peach and allied fruits to damage by scalding with arsenical sprays—and if this method is followed the poison should not be used in much greater amount than 1 pound of the arsenical to 400 gallons of water, previously mixing the poison up with an equal weight of lime in a small amount of water.

The experience in California with the arsenicals, as reported by Mr. Ehrhorn, has not been satisfactory. It has been found very difficult in actual practice to use them without danger to the plants. The winter treatment with kerosene emulsion, first described, is therefore especially and strongly advised.

FARMERS' BULLETINS.

The following is a list of the Farmers' Bulletins available for distribution, showing the number, title, and size in pages of each. Copies will be sent to any address on application to Senators, Representatives, and Delegates in Congress, or to the Secretary of Agriculture, Washington, D. C.:

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46. Irrigation in Humid Climates. Pp. 27.
47. Insects Affecting the Cotton Plant. Pp. 32.
48. The Manuring of Cotton. Pp. 16.
49. Sheep Feeding. Pp. 24.
50. Sorghum as a Forage Crop. Pp. 20.
51. Standard Varieties of Chickens. Pp. 48.
52. The Sugar Beet. Pp. 48.
53. How to Grow Mushrooms. Pp. 20.
54. Some Common Birds. Pp. 40.
55. The Dairy Herd. Pp. 24.
56. Experiment Station Work—I. Pp. 31.
57. Butter Making on the Farm. Pp. 16.
58. The Soy Bean as a Forage Crop. Pp. 24.
59. Bee Keeping. Pp. 32.
60. Methods of Curing Tobacco. Pp. 16.
61. Asparagus Culture. Pp. 40.
62. Marketing Farm Produce. Pp. 28.
63. Care of Milk on the Farm. Pp. 40.
64. Ducks and Geese. Pp. 48.
65. Experiment Station Work—II. Pp. 32.
66. Meadows and Pastures. Pp. 28.
67. Forestry for Farmers. Pp. 48.
68. The Black Rot of the Cabbage. Pp. 22.
69. Experiment Station Work—III. Pp. 32.
70. Insect Enemies of the Grape. Pp. 23.
71. Essentials in Beef Production. Pp. 24.
72. Cattle Ranges of the Southwest. Pp. 32.
73. Experiment Station Work—IV. Pp. 32.
74. Milk as Food. Pp. 39.
75. The Grain Smuts. Pp. 20.
76. Tomato Growing. Pp. 30.
77. The Liming of Soils. Pp. 19.
78. Experiment Station Work—V. Pp. 32.
79. Experiment Station Work—VI. Pp. 28.
80. The Peach Twig-borer. Pp. 16.
81. Corn Culture in the South. Pp. 24.
82. The Culture of Tobacco. Pp. 24.
83. Tobacco Soils. Pp. 23.
84. Experiment Station Work—VII. Pp. 32.
85. Fish as Food. Pp. 30.
86. Thirty Poisonous Plants. Pp. 32.
87. Experiment Station Work—VIII. Pp. 32.
88. Alkali Lands. Pp. 23.
89. Cowpeas. Pp. 16.
90. The Manufacture of Sorghum Sirup. Pp. 32.
91. Potato Diseases and Their Treatment. Pp. 12.
92. Experiment Station Work—IX. Pp. 30.
93. Sugar as Food. Pp. 27.
94. The Vegetable Garden. Pp. 24.
95. Good Roads for Farmers. Pp. 47.
96. Raising Sheep for Mutton. Pp. 48.
97. Experiment Station Work—X. Pp. 32.
98. Suggestions to Southern Farmers. Pp. 48.
99. Three Insect Enemies of Shade Trees. Pp. 30.
100. Hog Raising in the South. Pp. 40.
101. Millets. Pp. 28.
102. Southern Forage Plants. Pp. 48.
103. Experiment Station Work—XI. Pp. 32.
104. Notes on Frost. Pp. 24.
105. Experiment Station Work—XII. Pp. 32.
106. Breeds of Dairy Cattle. Pp. 48.
107. Experiment Station Work—XIII. Pp. 32.
108. Saltbushes. Pp. 20.
109. Farmers' Reading Courses. Pp. 20.
110. Rice Culture in the United States. Pp. 28.
111. The Farmer's Interest in Good Seed. Pp. 24.
112. Bread and Bread Making. Pp. 39.
113. The Apple and How to Grow It. Pp. 32.
114. Experiment Station Work—XIV. Pp. 28.
115. Hop Culture in California. Pp. 27.
116. Irrigation in Fruit Growing. Pp. 48.
117. Sheep, Hogs, and Horses in the Northwest. Pp. 28.
118. Grape Growing in the South. Pp. 32.
119. Experiment Station Work—XV. Pp. 31.
120. The Principal Insects Affecting the Tobacco Plant. Pp. 32.
121. Beans, Peas, and Other Legumes as Food. Pp. 32.
122. Experiment Station Work—XVI. Pp. 32.
123. Red Clover Seed: Information for Purchasers. Pp. 11.
124. Experiment Station Work—XVII.
125. Protection of Food Products from Injurious Temperatures. Pp. 26.
126. Farm Buildings.
127. Important Insecticides.
128. Eggs and Their Uses as Food.
129. Sweet Potatoes.
130. The Mexican Cotton Boll Weevil.

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FARMERS' BULLETIN No. 81.

CORN CULTURE IN THE SOUTH.

BY

S. M. TRACY, M. S.

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LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Office of Experiment Stations,
Washington, D. C., June 1, 1898.

Sir: I have the honor to transmit herewith an article on corn culture in the South, by Prof. S. M. Tracy, M. S., formerly director of the Mississippi Agricultural Experiment Station. The purpose of the article is to encourage the more extensive growing of corn in those portions of the South where its culture has hitherto been more or less neglected. Professor Tracy's long experience in experiment station work and his wide acquaintance with agricultural conditions in the Southern States have made it possible for him to prepare an article in which the combined results of investigations and experience on this subject are concisely stated.

I recommend the publication of this article as a Farmers' Bulletin.

A. C. True,
Director.

Hon. James Wilson,
Secretary of Agriculture.

CONTENTS.

	Page.
Introduction	3
The soil and its preparation	4
Rotation	5
Fertilizers	7
Varieties	11
Planting	14
Cultivation	16
Harvesting and storing the crop	19
Saving seed	22
Summary	23

CORN CULTURE IN THE SOUTH.

INTRODUCTION.

During the last ten years the rapid growth of the live-stock industry, the continually decreasing price of cotton, and the more general appreciation of the advantages of diversifying crops have led to a marked increase in the acreage of corn and a corresponding increase in the importance of this crop in all of the Southern States. This increase has not been sudden or irregular, but has come naturally with the gradual and constant change in conditions, and all indications point to a still greater increase in the near future.

It is true that the average yield per acre of corn in the South is not equal to that secured in the corn States of the Northwest, but that this is owing more to methods of culture than to differences in soil or climate is evidenced by the fact that the largest yield of corn on record—237 bushels per acre—was grown in South Carolina, and that the census of 1880 showed that the second heaviest yield per acre for any whole county in the United States was made in Issaquena County, Miss. So long as cotton commanded high prices the planter was satisfied to exchange it for corn. The best land and the best labor was given to cotton, and the corn, if any was grown, was given second choice in the division of the fields and only such labor and attention as could be conveniently spared from the cotton. No more corn was grown than was used on the plantation, and the supply was usually exhausted long before the new crop was ready for use, and often before it was planted. Under such conditions the corn crop was of only secondary importance, and was not relied upon as a market or a money crop.

With a continually increasing demand, however, more attention is now being given to corn, and wherever it has received the same care and attention which have been given to cotton the results have been fully as profitable and satisfactory.

The South has special advantages for the raising of corn, in the long season during which it may be grown and in the ready sale for the crop at remunerative prices. Planting may be done as early as February in the Gulf States, or it may be deferred until after a crop of oats or clover has been gathered from the land in June. Killing frosts rarely occur before November, so that even the latest plantings have ample time to mature, while the early plantings may be harvested in time for growing hay or for sowing winter oats or some other crop on the same ground. Notwithstanding the great increase the local demand is not yet fully supplied and in most localities the entire crop finds a ready sale in the home market and at prices which Western corn growers would regard as very high. In a few localities it has been sold occasionally as low as 25 cents per bushel, but that price has been rare and local, 50 cents per bushel being nearer the average through the Gulf States, the price being somewhat less than that in the northern section and higher farther south.

With a soil and climate well suited to its growth and with an increasing home demand for the crop the cultivation of corn is certain to become one of the leading farm industries of the South in the near future. Methods of culture and of handling the crop necessarily differ in many ways from those followed in other parts of the country, and it is the aim of this bulletin to describe briefly those practices which have been found most profitable and economical in the region south of the Ohio River.

THE SOIL AND ITS PREPARATION.

Any soil which will produce a good crop of cotton will also produce good corn, although dry, upland clay soils, which will make a fair yield of cotton when well fertilized, are not so well suited to corn as those which are richer in decayed vegetable matter (humus) and so suffer less from drought. Heavy crops of corn can often be grown on soils which produce a too-rank growth of cotton stalks without a corresponding amount of fruit. The best soil for corn is a rich, sandy loam which is well drained and which contains a fair amount of humus. As corn makes a rapid and succulent growth it should be grown on a soil which holds moisture well, and as the weight of the ears bears a close proportion to the size of the stalks the soil can not well be too rich. Humus is of more importance in the retention of moisture than any other one ingredient of the soil, and a loamy soil which is rich in this material seldom suffers from drought.

One of the best soils for corn is one on which red clover has been grown. Both crops flourish on the same kinds of soil, and the decaying stems and roots of the clover furnish a good part of both the humus and the food needed by the corn. When old clover fields are not available, land on which melilotus (sweet clover) has been grown is nearly or quite as good. In fact, any land which has made good crops of hay will make a good crop of corn immediately after the sod has been plowed. It is not always possible to secure fresh sod land on which to grow corn, and in such cases the preceding crop should, if possible, be cowpeas or vetches, both of which make a rank growth and furnish large amounts of humus which is rich in nitrogen collected from the air. The decaying organic matter also exerts an important solvent effect on the mineral elements in the soil.

Owing to the heavy winter rainfall in the Southern States plowing should be done only a short time before planting. Fall plowing for corn is seldom a good practice, excepting on new ground where a tough sod must be rotted before the soil can be made mellow. It is not a good practice to leave the bare soil exposed to the washing and leaching of the winter rains. For this reason, when tough sod land is to be planted in corn it is usually better to plow in the preceding spring or early summer and sow in peas, as the peas will rot and mellow the sod better than any other crop which can be grown, and corn seldom fails to make a heavy yield on land treated in that manner. The plowing should be deep and thorough, but whether subsoiling is profitable is still an open question. Many who have tried subsoiling have found it followed by such a marked decrease in the crop that they have abandoned the practice after the first season, while a few others have found it to produce a very satisfactory increase in the crop and regard it as a necessary part of the most economical method of preparing the soil for planting. The black prairie and river bottom soils are usually improved by both deep plowing and subsoiling, while heavy clays and light sandy lands give better yields when the plowing is not too deep.

Whether the plowing should be done flat or in beds depends on the lay of the fields. Lands which are sufficiently rolling to allow the surface water to run off quickly should be plowed flat, while creek and river bottom lands on which water is liable to stand after heavy rains will do better when plowed in beds. Formerly nearly all corn lands were plowed in 4-foot beds made by throwing four furrows together as is done for cotton, and the planting was done on the top of the bed. This practice is now being abandoned on all lands excepting those liable to overflow, and even there the beds are now often made 8 feet in width, giving room for two rows on each bed, which is much the better plan. Bedding requires more labor than plowing flat, has no advantages, and has many disadvantages on well-drained lands, and should never be practiced where it can be avoided.

The harrowing should be as thorough as the plowing, and there is no danger that it will be overdone. The harrow should follow the plow very closely in order to pulverize the soil before it becomes dried in hard clods, and if the land is not planted immediately the harrow should be used again just before planting to kill the germinating weed seeds. The labor expended in a thorough preparation of the soil shows its effects through the whole season in the better stand which will be secured, in the less amount of labor needed in cultivation, and in the increased yield.

ROTATIONS.

A crop of cotton occupies the land during the entire year and is a poor preparatory crop for corn, but where it is made the principal crop, as it will always be on many plantations, corn must sometimes follow it, and the best rotation must depend on the proportionate areas which are given to each of the two crops. Where two-thirds or more of the land is used for cotton, with no permanent hay fields, as is very common in the Yazoo Delta and many other rich alluvial regions, a common rotation is: First year, cotton; second year, corn and cowpeas and winter oats and vetch; third year, cotton.

This rotation is almost the only one possible where nearly all of the plantation is used for cotton. The corn should be planted as early as possible and at the last cultivation cowpeas should be sown between the rows. The crop can be harvested by September, when the ground should be sown at once with a mixture of turf oats and hairy vetch. The oats and vetch will grow through the winter, furnishing excellent winter grazing, or they may be cut for hay in April in time for planting cotton again. Where so little corn is grown it is almost always possible to find a place for it where some crop other than cotton was grown the previous year, and where such an arrangement of fields can be made it is always better than to put corn on land which has been in a hoed crop the preceding season.

Where only one-half the land is used for cotton, different rotations are more easily arranged. One four-year rotation which gives very good satisfaction is: First year, cotton; second year, cotton; third year, cowpeas and oats and vetch; fourth year, corn and cowpeas. In this rotation the corn is preceded by two leguminous crops, while the cowpeas grown with the corn leave the land in excellent condition for the following cotton crops.

Where red clover can be grown a better rotation is one which occupies the ground for four years, but can be extended to a longer time by repeating the cotton crop, as follows: First year, cotton; second year, cowpeas and clover; third year, clover; fourth year, clover and corn; fifth year, cotton. In this rotation the cowpeas are sown early in the spring of the second year and made into hay in September, in time for the sowing of clover. The clover occupies the ground all of the third year, and will give one heavy cutting in May of the fourth year in time to plow the land for corn. This is one of the best rotations for general use, as the cowpeas of the second year put the soil in fine condition for clover, and the clover is the best possible preparatory crop for corn. The land is occupied by corn and forage crops three years, and after such a preparation will make several successive cotton crops by the use of only small amounts of chemical fertilizers. In that way the rotation can be made to cover as many years as may be desired, and the land is never idle. Oats may be grown in the place of cowpeas, but as the crop is not one which is desirable for preceding clover it should be substituted only on a rich soil which is in a good mechanical condition.

W. C. Stubbs, of the Louisiana Experiment Station, recommends the following rotation for that State: Corn and cowpeas, oats and cowpeas, cotton. E. R. Lloyd, of the Mississippi Station, in speaking of the upland lime soil of that State, says: "If one-half the land is to be in cotton and the other half in corn, I would fertilize the cotton the first year with 250 pounds each of cotton-seed meal and kainit and would plant cowpeas in the corn at the last cultivation. The second year I would plant the corn land in cotton and fertilize with 100 pounds of cotton-seed meal and 200 of kainit, planting corn and cowpeas on the cotton land of the previous year. The third year I would plant cotton on the corn land and fertilize with 200 pounds of kainit. I would continue that alternation, using less commercial fertilizer and no meal after the second year, as the cowpeas, if plowed under, will be sufficient to maintain the fertility of the soil." J. F. Duggar, of the Alabama College Station, recommends the following: "First year, corn, with cowpeas between the rows if the land produces less than 20 bushels of corn per acre, followed by winter oats; second year, winter oats followed by cowpeas; third year, cotton. A more practical system, as giving a larger area in cotton, is a four-year rotation, begun as above, and completed with cotton in the fourth year." R. J. Redding,[1] of the Georgia Station, recommends the following for a three-year rotation:

Years.	Division 1.	Division 2.	Division 3.	Division 4.
First year	Small grain and cowpeas.	Cotton	Corn and cowpeas	Orchards, truck, forage, etc.
Second year	Cotton	Corn and cowpeas	Small grain and cowpeas.	Do.
Third year	Corn and cowpeas	Small grain and cowpeas.	Cotton	Do.

"In the above plan the farm, for convenience, is supposed to be divided into four approximately equal divisions. * * * On many farms the divisions might be extended to five, the fifth to include a more or less permanent pasture."

J. S. Newman, of the South Carolina Station, recommends corn and cowpeas, followed by small grain sown in the fall for the first year. The second year the small grain is followed by cowpeas, and the rotation is completed by cotton the third year.

Every planter will use a rotation to suit his own land and circumstances, and those given above may be modified to meet almost any requirements. Whatever rotation may be adopted, some leguminous crop, clover, melilotus, vetch, or cowpeas, should be grown immediately preceding the corn if possible.

FERTILIZERS.

As already suggested, red clover, cowpeas, and other leguminous plants are the best fertilizers which can be used for corn. On land which has produced a good crop of any of these plants very little additional fertilizer of any kind is needed to insure a good yield of corn the following season. The abundant supply of nitrogen furnished by these plants affords a large part of that needed by the corn, and in addition to this the forage crop makes available a large amount of other plant food in the soil which could not be reached directly by the corn roots. The humus left in the soil is as valuable in its effects as is the increased supply of food. The provision of an ample supply of humus is an essential item in economical fertilizing, and one which is too often overlooked. Humus is the great regulator of the supply of moisture, and it also has a powerful solvent effect on the potash and phosphoric acid in the soil. This solvent action is especially effective on the phosphoric acid, soils rich in humus having several times the amount of soluble phosphoric acid which is found in soils poor in humus.[1] Although humus from other sources appears to have the same moisture-regulating and solvent effects, still the use of leguminous plants for its production is more economical, as such plants draw a large amount of nitrogen from the air and leave it in the soil, and thus provide the most expensive element of fertility without cost.

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[1] Georgia Sta. Bul. 37.

When for any reason the land can not be made fertile by the growing of legumes, barnyard manure is next in value as furnishing the necessary humus and nitrogen, though it should ordinarily be supplemented with potash and phosphoric acid. Barnyard manure varies so widely in composition that no exact value can be assigned to it, nor can any definite rule be made as to the amounts which should be used on different soils. Ordinarily its greatest value is in its humus-making capacity, and this is especially true in the South, where it is seldom kept under cover and where the soluble potash and phosphoric acid are largely leached out and the nitrogen lost in the air before the manure is spread on the land. This loss of fertilizing elements can be largely avoided by hauling the manure to the field as fast as it is made, but that is not always practicable. If barnyard manure alone is used as a fertilizer there is little danger that the application will be too heavy. Ordinarily it is better to apply it broadcast before plowing, and it is better to give a part of the field a heavy dressing once every few years than to make a very light application over the whole every year. If the manure is fresh and coarse, full of cornstalks, straw, and other rubbish, it should be used on clay rather than on sandy soils, while if fine and well rotted it will be more effective on the lighter soils. Less than 20 wagonloads per acre will not often produce marked results, and if 50 loads per acre are available they can be used with profit. The manure will be much more effective if from 100 to 200 pounds per acre of acid phosphate is mixed with it when it is hauled to the field, and, at planting, the same weight of kainit or one-fourth as much muriate of potash should be used under the seed.

When neither green manuring nor barnyard manure is available, cotton seed, cotton-seed meal, potash salts, and phosphates must be used, the quantities and proportions varying with the character of the soil. The necessary supply of nitrogen can be secured most economically from either cotton seed or cotton-seed meal, the former being better for heavy, clay soils, while the latter is more effective on light, sandy lands. Nominally 1 pound of the meal has a fertilizing value equal to that of 2½ pounds of seed, but their relative effects may vary widely from those proportions. The seed furnishes a much larger amount of humus than does meal containing an equal amount of plant food, and so is more effective on soils which have not recently been fertilized with vegetable matter. The whole seed makes a heavy soil lighter, looser, and more easily worked, while meal has the contrary effect. The whole seed is more lasting in its effects than is meal, a considerable part of it not being exhausted before the end of the second season.

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[1] Minnesota Sta. Buls. 30 and 41.

The common practice of wetting the seed and allowing it to heat sufficiently to kill the germ before using it is wholly unnecessary when it is used as a fertilizer for corn, as it is used so early in the season that nearly all of it will be killed in the ground, and even if a few seeds should germinate, the young plants will be killed by the first cultivation and will decay so quickly that nothing will be lost. When the whole seed is used, from 25 to 50 bushels per acre is a fair application.

Cotton-seed meal is better than the whole seed for use on light soils. It makes such soils more compact, and thus less easily affected by drought, which is often an important item on the soils of the pine woods and Gulf region. It decays and becomes available for plant food very quickly, and nearly all of its fertilizing value will have been exhausted by the end of the growing season. From 200 to 400 pounds per acre may be used to advantage, and, like the seed, it should be supplemented by the addition of potash and phosphoric acid. When the larger amount is to be used, especially on soils which are very light, it is better to use it in two applications, the first being made in the drill just before the corn is planted, and the other at the time of the last cultivation, when peas should be planted between the rows. The best general rule is to use whole seed on heavy soils and for lasting effects, and meal on light soils and for quick results.

Corn has a comparatively long period of growth, covering that part of the year when decomposition goes on quite rapidly in the soil. For this reason it utilizes to best advantage the slow-acting nitrogenous fertilizers, such as green manures, barnyard manure, cotton seed, cotton-seed meal, etc.

Potash can be best secured either as kainit or as muriate of potash. The actual potash in each appears to be equally available and valuable, so the choice between the two will depend on their relative prices. As a ton of the muriate contains four times as much potash as a ton of kainit, the consumer can afford to pay, including freight, four times as much for it. When freight forms any large part of the expense, the muriate is usually the cheaper form. Cotton-hull ashes are worth more than twice as much as kainit, as they contain nearly double the amount of potash in addition to nearly 9 per cent of phosphoric acid, and are the more economical fertilizer when they can be bought for double the price of kainit. The amount of potash needed varies greatly for different localities, and no definite rule for its use can be formulated. In the work of the Louisiana Station it has rarely proved necessary or profitable. The Mississippi Station found it more beneficial than phosphoric acid on upland lime soils, and equally necessary in the coast region, while in the pine woods region of the State it produced little or no effect. At the Alabama Station its effects have been uncertain, apparently producing a marked increase in the crop at some times and being wholly ineffective at others. At the Georgia Station it has also been very uncertain in its action, though more often beneficial. Results of experimental work in South Carolina and Florida have been exceedingly variable, while at the Kentucky Station potash has uniformly given good returns. In all of the Southern States it has been impossible to make reliable predictions as to the effects of potash on untried soils, though there is no doubt that less is needed on fresh land than on that which has been long in cultivation, and that it is more effective on lime soils than elsewhere.

Phosphoric acid can usually be secured in form of acid phosphate at less cost than in any other form. The field tests made at all the Southern stations indicate its need on all soils excepting perhaps those which are very rich in lime. On strong lime soils its effects are not certain, and it is not as uniformly profitable as when used on the pine woods and coast soils. When used on a soil colored red by iron a large part of the phosphoric acid soon combines with the iron and becomes insoluble and inert. For that reason it is more effective when used on a soil rich in humus, and before it is spread upon the land it is better to mix it with the manure, cotton seed, or meal than with the kainit or muriate. From 200 to 300 pounds per acre is a fair amount for use.

As has already been stated, there can be no definite and invariable rule in regard to either the composition or amounts of fertilizers which should be used for corn, as both must be regulated by the natural character of the soil on which they are to be used and by the previous treatment of the land. W. C. Stubbs, of the Louisiana Station, says: "The crying need of the hills and bottom lands of Louisiana is nitrogen, and this has its best effects when combined with phosphoric acid. Upon the bluff lands we find that the reverse is true; that the crying want is phosphoric acid, and the best results are secured when combined with small amounts of nitrogen." E. R. Lloyd, of the Mississippi Station, says: "I recommend 250 pounds each of cotton-seed meal and kainit per acre, applied in the drill. If used broadcast double those amounts should be used. I prefer a good rich compost to either." J. F. Duggar, of the Alabama College Station, recommends the use of coarse manure and cotton seed under corn, supplementing the cotton seed with acid phosphate. The results of several years' work at the Georgia Station[1] indicate that a fertilizer for corn, on the average soils of middle Georgia, should contain phosphoric acid, potash, and nitrogen in about the following proportions:

	Per cent.
Available phosphoric acid	7.00
Potash	1.30
Nitrogen	3.40

These proportions would be furnished by the following mixture:

	Pounds.
Acid phosphate	1,000
Muriate of potash	55
Cotton meal	1,000
Total	2,055

The muriate of potash may be replaced by 200 pounds of kainit.

J. S. Newman, of the South Carolina Station, recommends cottonseed meal and acid phosphate in equal quantities, using 400 pounds of the mixture in the drill.

Most commercial fertilizers absorb moisture from the air so quickly that it is difficult to distribute them satisfactorily by the use of any machine. Probably the best implement for the purpose is a cotton planter with an agitator which will prevent the fertilizer from clogging or becoming banked against the sides of the feed box. By the use of such an implement the amount distributed can be regulated very accurately, and the fertilizer is placed below the seed bed and is so well mixed with the soil that there is no danger that it will burn the tender rootlets of the young plants. When such an implement is not available very good work can be done by fastening a section of a horn or even a tin spout in one corner of the bottom of a stout bag which is filled with fertilizer and slung over the shoulder. The opening in the lower end of the horn must be of such size that it will not clog and that the flow of fertilizer may be easily regulated by the hand. A little practice will enable the workman to distribute the fertilizer as evenly as is necessary. It is easy to estimate the part of an acre occupied by two rows, and from that the workman will soon learn to gauge his distribution. If the fertilizer is distributed by hand the drill should first be opened by a small plow, the fertilizer then distributed, and if the planting is to be done with a planter it may follow at once, but if the corn is to be dropped and covered by hand it is better to follow the distributor with a bull-tongue plow to mix the fertilizer with a few inches of the surrounding soil.

VARIETIES.

For all ordinary purposes the best variety of corn is the one which will produce the greatest amount of shelled grain per acre, regardless of the time of ripening or of the size of either stalks or ears. In the

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[1] Georgia Sta. Bul. 37.

South the growing season is so long that it is not necessary to select quick-growing varieties. The heaviest yields are commonly secured from varieties which require from 140 to 170 days for their full maturity. If the crop is to be planted on ground from which oats, clover, or some other early crop has been harvested, or on land which has been overflowed until late in the season, some of the earlier maturing sorts should be planted; but when the corn is planted early in the spring any variety will have ample time to mature before frost, and the longer period of growth will produce the larger yield.

From the results of hundreds of tests at experiment stations in all parts of the country it appears that heavier yields can be secured from white than from colored varieties. In 1,267 comparative tests with 490 varieties the average yield of 217 white varieties has been 2.5 bushels per acre in excess of the average yield of the 273 colored varieties grown in the same tests.[1] At only one of the stations from which such tests have been reported have colored varieties given the heavier yield. Of course this does not indicate that all white varieties are more productive under all circumstances than is any yellow variety, but such uniformity in results secured in all parts of the corn-growing section of the country does indicate very plainly that of all the varieties adapted to any special locality some one or more of the best white varieties will produce more grain than will any of the colored varieties. In this connection it is interesting to note that the white varieties of wheat and oats also give larger yields than do the colored varieties of the same grains.

Whether white or colored corn is better for feeding is a matter of dispute. Many feeders claim that colored corn is "stronger," i. e., that it is more nutritious and fattening than white corn, but there appears to be no reliable foundation for the belief. Chemical analyses show no constant or material differences in the composition of different varieties. Jenkins and Winton[2] give the composition of 30 varieties of white dent and 28 of yellow dent corn as follows:

Composition of white and yellow corn.

	Protein.	Fat.	Nitrogen-free extract.	Fiber.	Ash.
	P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
White	11.6	5.8	78.4	2.5	1.7
Yellow	11.5	5.4	78.9	2.5	1.8

No experiments to determine the relative digestibility of different colored varieties have been reported, but with so little difference in their composition it is highly improbable that color alone in any way affects their feeding values.

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[1] Mississippi Sta. Bul. 33.

[2] U. S. Dept. Agr., Office of Experiment Stations Bul. 11.

There are considerable differences in the root systems of different varieties, and these differences may often be sufficient to be of importance in deciding on the relative merits of different sorts. Strong and well-spread roots are necessary to hold the stalk erect after it reaches maturity, or there will be a loss from the decay of ears on stalks which have fallen or been blown down before the crop is gathered. If the stalks are to be cut for fodder or if the crop is to be gathered as soon as it is matured, a strong root system is of less importance, but if the crop is to remain in the field any length of time after it is ripe it is very desirable that it should be on stalks which will not fall to the ground. Colored varieties often have stronger root systems than do white varieties, and so are usually preferred when the crop is not to be gathered until late in the season. Very prolific white varieties, like Blount Prolific, have weaker roots than the single-eared yellow varieties, like Evans or Leaming, though most single-eared white varieties have roots sufficiently strong to hold the stalks erect. In many yellow varieties the grain is harder than in most of the white varieties, and so is less liable to decay if it falls to the ground, and is less liable to suffer from insects. All of these points should be considered in deciding on the variety to be planted. In general the white varieties will give the heavier yield, and are the better when the crop is to be gathered as soon as matured and is protected from insects until used; while if the ripened crop is to remain in the field several weeks, some of the more hardy colored varieties will be more satisfactory.

Whatever may be the color of the grain the ears will be larger when only one is borne on a stalk than when each stalk produces two or more. The general experience of Southern cultivators has been that larger yields have been secured from varieties producing two medium-sized ears on each stalk than from those which produce only one large ear, while varieties which bear from five to eight ears per stalk invariably give small ears with short grains and a smaller weight of grain per stalk than is given by two ears of medium size and good length of grain.

The cob should be small in proportion to the size of the ear. While it is true that "a large cob will hold more than a small one," it is not true that 70 pounds of ears with large cobs will have as much grain as an equal weight of ears having smaller cobs. When the cob is small, as in the Mosby, 70 pounds, or a bushel of ears, will give from 62 to 63 pounds of grain, while if the cob is large, as in the Parrish and Conscience, the same weight of ears will give only from 53 to 55 pounds of grain, a difference of nearly 20 per cent in favor of the smaller cob. If an acre will produce only a certain number of ears, the larger the ears the larger will be the yield of grain, but it is found by experience that with a variety producing ears of medium size an increase in the size of the ears is accompanied by a decrease in their number, and that the greatest amount of grain is secured from varieties which produce from

175 to 200 ears on each 100 stalks. It is better to maintain that number of ears and to increase their size if possible than to increase the size at the expense of numbers. Large cobs are usually soft and are often actually open at the butt, giving free entrance to rain, so that injury from becoming water-soaked and molded is much more common than with smaller cobs.

The position which the ear assumes in ripening is a matter of considerable importance in the selection of a variety. If the ripened ear remains erect, rain will find its way between the loosened husks at the top and will often be held by the closer husks at the butt. Under such circumstances a few warm days will cause the grain at the butt to sprout or rot. If the ear bends over in ripening so that the top hangs downward, there can be little injury from even long-continued rains.

Throughout the South the dent varieties give larger results than the flint varieties, while the so-called "starch corns," like the Hickory King, have been too soft and too subject to insect injuries to be satisfactory.

Named varieties of corn are so numerous, so local, and so changeable that it is useless to attempt to describe all or even to name any which are superior to others. The best variety for any locality is the one to which the most intelligent care has been given in the selection of seed during the last few generations. Seed from almost any variety which has been selected with care, as described on page 22, during four or five years will give better results than seed which has been taken at random from a crib of any variety. When grown for ordinary purposes the variety should have the following characteristics:

(1) It should be a dent rather than a flint variety.

(2) It should have a growing period of from 150 to 170 days.

(3) The stalks should have well-developed roots and should average nearly two ears each.

(4) The ears should be of good size, of uniform diameter throughout, well filled at both ends, and should point downward when ripe.

(5) The cobs should be small in proportion to the size of the ear.

(6) The individual grains should be long and so broad at the upper end as to leave only a slight depression between the rows.

(7) The variety should be of local origin.

PLANTING.

Whether corn should be planted flat or on raised beds will depend on whether the land has good natural drainage or is liable to suffer from overflows. With good drainage flat planting is much the better, because preparation is less expensive and because it exposes less surface for the evaporation of soil moisture, and thus makes the crop less liable to suffer from drought. It is not unusual to see corn planted in 4-foot beds which are raised from 9 to 12 inches above the adjoining water furrow. If the top of the bed is only 9 inches above the water furrow the amount of surface between the rows is increased 4 inches, exposing

8½ per cent more surface for evaporation, which will often make the difference between success and failure when drought comes at a critical time in the growth of the crop. On hill lands when the corn is planted in drills each drill will form a slight ridge sufficient to prevent washing in ordinary rains, and all ridging beyond that should be avoided on such lands.

On poorly drained bottom lands, which are liable to suffer from overflows, bedding is often advantageous in hastening the drainage, and thus enabling the soil to become dry and warm enough for planting a few days earlier in the spring. Where any bedding must be done, it is better to make the beds 8 feet wide, or wide enough for two rows, with water furrows in the alternate spaces. In that way each row has a water furrow on one side, which is ample for carrying off surplus rainfall; the beds can be made higher with the same slope, though exposing less surface than the 4-foot beds, and the drainage is more thorough.

The rolling lands of the South so often suffer from washing that it is usually necessary to preserve them as much as possible by planting in drills rather than in checks. The rows should run at right angles to the slope of the hill, so as to keep them as nearly level as possible, and although this makes the rows irregular in length and in distance apart, it is the only safe plan to follow on lands which wash. In most cases "circling" the rows around a hill is fully as effective as is the ordinary form of terracing, as each row forms a miniature terrace 4 feet wide and no space is lost.

On fairly level lands, and on all lands which do not wash, the crop can be cultivated at slightly less expense when planted in checks, though it is commonly believed that the yield is slightly less. It is much easier to place the fertilizer evenly under drills than under hills, though when in drills all of the cultivation between the plants in the drill must be given with the hoe. The least expensive method of cultivating an acre of corn is to plant it in checks, and so avoid the use of the hoe; but the heavier yield can be made in drills, which distribute the plants more evenly over the ground, and planting in drills is the better plan when labor is not too expensive.

Drills are commonly placed 4 feet apart, as that gives a convenient width for cultivating; but the distances between the plants in the drills which are preferred by different planters vary greatly. Of course, the nearer the rows are placed to each other and the closer the plants in the drill, the greater the number of plants on an acre; but too many plants crowd each other, so that none can produce good ears. The richer the soil, the closer can planting be done with safety.

The amount of seed needed per acre is the same, whether the planting be done in hills or in drills, 8 quarts being the usual amount used.

The best depth for planting varies with the temperature and the moisture of the soil. The seed should be placed so deep that it will not suffer from dry weather immediately after planting, but not deep enough to be placed where the soil is cold and wet. When the seed is dropped on the surface of the ground and covered by a hoe in favorable weather it will germinate quicker than when buried 2 or 3 inches below the surface, as is done by a planter, and is less liable to decay if the planting is followed by several days of cold and wet weather. If, however, the soil is very dry at the time of planting and dry weather continues for some time, the shallow-surface planting will fail to give as even a stand as the work done by a planter. Early plantings should not be covered more than 1 inch deep, while very late plantings should be covered with 2 or 3 inches of soil. Many believe that corn which is planted shallow will make more suckers than that which is planted deeper, but the number of suckers depends more on the variety than on depth of planting.

The use of a horse planter is less expensive than hand planting; the distribution of seed will be more even, and the planter should be used whenever the ground is in proper condition. There are a number of both one-horse and two-horse planters, all of which do satisfactory work. Whatever style is adopted the planter should be one which can be easily adjusted to distance and depth and to size of grain; it should permit the operator to see the seed as it drops from the feed box to the delivery pipe, and it should be provided with a roller to insure the covering of the seed and the compacting of the soil above the seed. A two-horse planter for either hills or drills is usually preferred for large and level fields, but for small and irregular fields and in fields where the rows are to be circled about the hills a one-horse planter is more convenient.

Whatever method of planting may be adopted, the work should not begin too early in the season. Nothing is gained by putting seed into soil which is too cold or too wet to favor germination. It is better to defer the planting a week or ten days than to run the risk of losing it by decay or of having an imperfect stand by planting before the ground is sufficiently dry to work well and warm enough for immediate growth. Every missing plant means a decrease in the yield, and replanting the missing hills is seldom profitable. The replants are surrounded by plants which mature and shed their pollen before the younger silks are formed. The pollination is therefore very imperfect, and the ears on the replants are usually nubbins, which are scarcely worth gathering. When the missing plants amount to from 10 to 20 per cent of the whole, replanting with some earlier maturing variety which will produce its tassels and silks at about the same time as the original planting is often profitable, but will not pay when the misses are less than 10 per cent. When the misses are more than 20 per cent it will pay better to make an entire new planting.

CULTIVATION.

The nearer level and smooth the surface of the ground can be kept the better. Thorough cultivation is needed, but that does not mean deep cultivation. While corn does best on a soil which is deep and loose, the deepening and loosening of the lower soil should be done before the corn is planted, and the shallower the later cultivations can be kept the more satisfactory will be the results. Corn has no large taproot like that of cotton, but is a surface feeder, having a large number of long roots distributed through the upper soil, and whenever the soil is cultivated so deep as to disturb any of the roots the plant is necessarily weakened by having its supply of moisture and nourishment decreased. A constant supply of food is as necessary to a growing plant as to a growing animal, and the cutting off of so many of the corn roots as is done by cultivating 4 or 5 inches deep gives the plants a check from which they never fully recover. Cultivate the ground deeply before planting and as shallow as possible afterwards.

Cultivation should begin immediately after the first rain that follows the planting. There is no better implement for this work than a light smoothing harrow with slender teeth pointing backward. One drawn by two mules can go over 10 acres in a day very easily, and there is no other way by which a thin crust can be broken so readily and so many germinating weed seeds killed. When the soil is very fine and mellow and the crust is not too hard, good and rapid work can be done with a horse weeder, an implement with long teeth similar to those of a hay-rake, but much closer together. Only one mule is needed to draw the weeder, and it is a very satisfactory implement where the soil is in good condition for its use, though too light to break a heavy crust or to kill weeds when more than an inch in height. Where the ground is rough or has many hard clods the harrow is much better than the weeder. Cultivation should follow each rain to prevent the formation of a crust and to kill weeds as soon as they germinate, and the harrow or weeder is the best implement to use until the corn is at least 6 inches high. It is true that the later harrowings will leave the corn looking somewhat torn and ragged, but it will recover very quickly and no permanent injury will result.

The corn should be hoed and thinned to the proper number of stalks when it is from 4 to 6 inches high, as it will then be past danger from bud worms, cutworms, and other insects which often attack the young plants soon after they appear, but which seldom do any injury later in the season. At the same time any weeds which may be growing in the rows between the stalks should be cut out, and if this hoeing is carefully done the crop will need no other hand work. After the corn becomes too large for using a harrow, the best work can be done with a light side harrow or with a cultivator having from five to seven teeth and running not more than 2 inches deep. The old practice of "bleeding" corn by a very deep cultivation toward the end of the cultivating season is never beneficial and is usually quite injurious, and especially so if the bleeding is done at the beginning of a drought.

While it may sometimes be advantageous to "ridge up" corn by throwing soil toward the rows at the time of the last cultivation, if this can be done only at the expense of cutting or uncovering the roots between the rows it should always be avoided. The principal advantage claimed for the ridging is that it assists the brace roots of the corn to take a better hold upon the soil and thus prevent the stalks from being blown down so easily by heavy storms. While this claim has some good foundation, still the excess of stalks blown down where they are not ridged will not repay the injury to the whole crop which is sure to result from a wholesale cutting of roots just at the time when they are most needed to develop the newly formed ears. It is a commonly accepted fact that "root pruning promotes seed production," but in this case the root pruning is done too late. The seeds have already been formed, and what the plant needs at this time is an uninterrupted supply of nourishment to enable them to develop to their fullest size. If root pruning is ever beneficial it is before the seed are formed, and when done later its only effect is to dwarf both plant and seed.

Several of the experiment stations have tested the relative advantages of the deep and shallow cultivation of corn very carefully, and the results of many such tests have already been reported. The records of 116 such tests made at 13 different stations show that 61 tests of deep cultivation gave an average yield of 64.9 bushels per acre, while 55 tests of shallow cultivation gave an average yield of 74.7 bushels per acre, a difference of more than 15 per cent in favor of shallow cultivation. In only 5 cases out of the entire number reported did the deep culture give the better results.

On large and fairly level fields some form of two-horse riding cultivator is often used, the disk cultivator being more popular than any other. With these implements it is not difficult to cultivate as much as 8 acres in a day, and such rapid work makes cultivation very inexpensive. By planting in checks, so that cultivation can be given in both directions, and by the use of the harrow for the earlier cultivation and a two-horse cultivator for the later work, the total expense for labor in preparing the land, planting, and cultivating, does not exceed $1.50 to $1.75 per acre. This plan is now being followed on many large plantations, but many who have tested the matter quite thoroughly have come to the conclusion that more thorough though more expensive cultivation is more profitable in the end.

Whatever system may be adopted the cultivation should be sufficiently frequent to keep down all weeds and to break the surface crust after every rain. In time of drought the cultivation should be as frequent as possible. Deep cultivation at such times is often ruinous, but when only 1 or 2 inches of the surface soil is stirred evaporation is checked, and although the surface may become very dry and dusty the soil immediately below this "dust mulch" will remain fresh and moist much longer than when the surface is allowed to become compact, even though not crusted by rains. At the usual prices for corn and for labor in the South 1 bushel of corn will pay for a single cultivation of 2 acres of land. Much of the corn grown in this section is cultivated only three times, though it is the uniform experience that more frequent cultivations result in a greatly increased yield. An increase of only 2 bushels per acre is ample pay for the three additional cultivations, and it is rare that the additional labor does not give a good profit. Corn often suffers seriously from the want of cultivation, but never from too frequent, shallow stirring of the soil.

HARVESTING AND STORING THE CROP.

The more common method of harvesting the crop is to "pull" the ears, with a good portion of the husks attached, leaving all the fodder in the field. After the crop has been gathered hogs and cattle are turned into the fields and so a portion of the fodder is utilized. This seems like a wasteful method, but in a region where the cornstalks are usually large and coarse and where hay can be made and saved with so little expense it is often the most economical and profitable plan. Whether to cut the stalks and save them for coarse feed or to give cattle the range of the field and use the labor in making other hay depends on the amounts of feed which can be secured by equal amounts of labor. When the entire stalk is saved the yield of dry forage per acre is from 1½ to 2 tons, and of that amount approximately one-fourth, and that the part which is the most palatable and has the greatest feeding value, may be saved by turning stock into the field. Taking into account the amount which will be gathered by cattle without expense and the various losses in handling and feeding the stalks the total additional amount of feed saved by cutting is rarely more than 1 ton per acre. To secure this additional ton the entire crop must be cut, and in order to make more than half the weight of fodder available for food all must be run through a shredder, thoroughly dried, and stored in a dry place. The palatability of the shredded fodder varies greatly. If the cutting is done early, while the upper leaves are still green and the stalk is not yet dry, the yield of fodder will be much heavier and of much better quality than when the cutting is done later, but the early cutting will cause a loss in the grain yield and the fodder will be more difficult to cure. As already remarked, the only object in saving the fodder is to secure a given amount of forage for feeding stock. On many plantations an equal amount of forage of better quality can be secured if the labor necessary for saving the corn fodder is used in making and saving hay, and the farmer who adopts either of the rotations suggested on a previous page will rarely find it profitable to cut, shred, and house his cornstalks.

The results of two years' work at the Alabama College Station[1] gives the stalks a value of $2.95 per acre over the amount received when only the ears were harvested, and whether that amount, less the value of the standing stalks, is sufficient to cover the cost of cutting and handling the fodder is a question which each planter must decide for himself.

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[1] Alabama College Sta. Bul. 88.

When the corn crop is to be followed by a September or October sowing of clover or any other crop for mowing it will pay to cut the stalks to get them out of the way, and when the labor of cutting is necessary for the success of the succeeding crop it will usually pay well to save the stalks for fodder, as the additional expense will be slight.

"Topping" corn, i. e., cutting off the stalk just above the ear after the grain begins to harden, gives a much better fodder than is obtained by harvesting the whole stalk, but the labor involved is considerable, the yield of fodder light, and the injury to the grain yield is usually greater than the value of the fodder secured. At the Mississippi Station[1] the removal of the tops during three seasons caused an average decrease of 20 per cent in the grain yield. This large decrease in grain was doubtless due partially to cutting the tops too early, but at other stations where similar tests have been made the average decrease in yield has been 16 per cent, and the value of the fodder secured has rarely equaled that of the grain lost.

Stripping the leaves from the stalks (a very common practice in all parts of the South) is also of doubtful economy, especially when the work is done by hired labor. More or less ears are sure to be broken off and lost. If the stripping is done early the yield of grain is decreased, and if done late the fodder secured is of but little value. It is often the case that laborers are glad to pull the fodder on shares, taking one half and giving the owner the other half. If the crop is well matured before the pulling is done this will be profitable to the owner, but the fodder will rarely pay for the labor when it must be pulled by hired labor.

If the securing of a certain amount of forage is the only object it will seldom be profitable for the Southern planter to hire labor to gather either the whole stalks, the tops, or even the leaves from his cornfields when he has land on which he can grow hay and stock to graze the cornfield after the crop has been gathered. If he has labor which would otherwise be idle, or if it is desirable to clear the ground for the immediate sowing of some other crop, the fodder is well worth saving, even though it makes forage of an inferior quality.

When corn is to be used during the winter for feeding fifteen or more milch cows it is economical to use a part of the crop in filling a silo. A silo of sufficient size to hold 25 tons, or feed for 20 cows 100 days, can be built for about $100, while one of larger size can be built for much less expense in proportion to its capacity. The average cost of growing the corn and filling the silo is about $1 per ton. The crop of stalks from an acre will require about the same amount of storage room, whether it is placed in a silo or is preserved as shredded fodder, though the building for the silo must be much more substantial than that needed for sheltering the fodder. The silage will give much better satisfaction than fodder for feeding milch cows, but the fodder is considered preferable for horses or mules. The same power and the same machine which are used in shredding the stalks may be used in preparing the silage.

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[1] Mississippi Sta. Bul. 33.

The common practice of gathering and storing corn with the husks still inclosing the ears is advocated by many from a belief that the husks serve to protect the grain from the attacks of insects which are often very destructive to stored grain. The two insects which are most destructive to stored corn are the Angoumois grain moth (*Gelechia cerealella*) and the black weevil (*Calandra oryzæ*), and as the corn is often infested by one or both of these insects while still in the field there is little to support the idea that the husks serve as a protection. Insects which find their way so quickly to the bottom of a bin filled with oats or through the meshes of a closely woven cloth bag will not be hindered from finding corn which is only partially inclosed by husks. The husks add materially to the bulk of the stored corn, they afford no protection from insects, and provide the best of nesting material for rats and mice. The corn must be husked before it can be shipped, and most of it before it can be used. Husking can be done more rapidly and with less expense as the corn is being gathered than at any other time, and under ordinary circumstances that is the best time for doing the work.

If corn is to be stored only a short time the ordinary open crib is all that is necessary, but if it is to be kept until spring before using the sides and bottom of the crib should be tight, so that the corn can be treated with bisulphid of carbon to kill moths and weevils. If thoroughly dry when brought from the field it may be stored in such a bin with no danger from heating or molding, and if treated at once by pouring bisulphid over the top of the corn, using one pound of the liquid for each 100 bushels of grain, it will be secure from insect depredations for several months. If the corn is kept until late in the season it should be watched during the spring, and if either moths or weevils should be found it should receive another treatment. If the corn is damp when gathered it will not be safe to put it in a close crib which is not well ventilated, while if placed in an open crib it can not be treated for killing insects. If no insects can be found in the corn when it is gathered immediate treatment is not necessary, as there will be but little danger of loss in the grain which is used during the winter. If already infested, however, it should be treated at once. Many who prefer to use an open crib for permanent storing place the corn first in what is known as a "quarantine bin," where it is treated and then removed to the cribs where it is to remain. The quarantine bin may be one which has been built for the purpose, but is more often a convenient corner of the barn which has been boarded up so as to make the sides close, and which is of sufficient size to hold 100 bushels or more. The corn is placed in this bin as it is gathered, and when it is filled 1 pound of bisulphid for each 100 bushels of grain is poured over it and the top is covered with a tarpaulin or with old sacks to confine the fumes of the liquid. By the end of the third day all the insects will have been killed and the corn may be removed with perfect safety. If the cribs where the corn is to be stored have previously been infested with insects they should be treated with bisulphid before the new corn is gathered. The only special care necessary in using the bisulphid is to prevent an explosion from fire, as it is very easily ignited, and no lantern or light of any kind, or even a pipe, should be allowed in a building where it has been used so long as any of its odor can be detected, which will rarely be more than three days after its application. The bisulphid is not expensive, costing only 10 cents per pound when bought in 50 pound lots, and its use does not injure the corn for feeding, grinding, or for planting.

China berries, Jerusalem oak, salt, and other things are often recommended as preventives of insect attacks, but are of little if any value.

SAVING SEED.

Corn is a plant which varies so quickly and can be modified so easily by planting seed from any desired form that constant care in the selection of seed is as important as intelligent cultivation. The period of growth may vary from 80 to 200 days, the height of the stalk from 6 to 16 feet, and the number of ears on a stalk from 1 to 8 or 10. Some stalks produce several branches or "suckers," while others remain strictly single, and in some the cob has fully three times the diameter it has in others. The size and shape of the grain shows equal differences, and color is almost the only permanent character found in any of the hundreds of varieties in cultivation. This variability is due, partially, to a natural tendency to variation and still more to the fact that each ear is usually fertilized by pollen from many different stalks and so may give crosses between the plant on which it was grown and a score or more of those which surrounded it. Although it is possible for a plant to vary widely from the one on which the seed was grown the probabilities are strong that it will have a close resemblance to its parent, and therefore seed should be selected from only those stalks which are nearest to the form and habit desired. For all ordinary purposes the value of a variety depends on the amount of shelled corn which it will produce per acre. This in turn depends fully as much on the growth and productiveness of the individual stalks as upon the size and shape of the separate ears, and for that reason seed should always be selected in the field rather than from the crib.

The best plan for saving seed is to go through the field before the crop is harvested and gather the best ears from the best stalks. The largest yields of grain are usually made from varieties producing two ears on each stalk, and if such a variety is desired then seed should be saved only from stalks bearing two ears. It is sometimes claimed that the upper one of two ears will produce the earlier maturing crop, but in the South early maturity is of so little importance that if a stalk has two good ears both should be taken; if one ear is good and the other only fair the better one may be taken; while if either ear is very poor in size, shape, or fullness both should be rejected. If a variety bearing only one ear to each stalk is preferred the ears selected for seed should be the largest which can be found, of nearly equal diameter throughout, and well filled at each end. It is as important to take seed from the best stalks as from the best ears, and whatever variety may be preferred every ear which is selected for seed should be taken from a stalk which in size, habit of growth, and number of ears approaches closely to what is the desired form for that variety.

If careful hands are employed in gathering the crop a very good selection of seed may be made by having a box in the wagon into which the most desirable ears may be thrown as they are found.

In selecting seed from the crib, as is often done, nothing can be known of the character of the stalks upon which the ears were grown, and little or no improvement can be made in a variety by such a selection; while a careful and judicious selection in the field will work a constant and gradual improvement in the crop and will make it more nearly uniform with each succeeding year. No one item in the growing of corn is of greater importance than the selection of seed.

After the seed has been selected it should be thoroughly dried, treated with bisulphid of carbon to destroy insects, and then stored where it will be kept dry and secure from rats and mice.

It is a somewhat common practice to discard the tips and butts of the ears when shelling the seed for planting, but the practice is oı doubtful benefit. A number of the experiment stations in both the North and South have made repeated tests of the productiveness of seed from different parts of the ear, but these tests have shown no marked or constant differences in yield, even when the selections have been repeated through several generations.

SUMMARY.

(1) The best soil for corn is a rich sandy loam which contains a good supply of humus. Land which has been used for growing red clover, melilotus, cowpeas, or other leguminous crops is much better than that which has been used recently for hoed crops.

(2) In using manures and fertilizers it is better to use the coarse stable manure and the whole cotton seed on the heavier soils, and the well-rotted manure and the cotton-seed meal on the lighter soils.

(3) All well-drained lands should be plowed flat, and high beds are advisable only on lands which are subject to overflows. When beds are used they should be wide enough for two rows each.

(4) The best variety of corn for ordinary purposes is the one which will produce the greatest amount of shelled grain per acre, regardless of the number or size of the ears.

(5) White varieties will usually make a heavier yield than colored varieties, though many colored varieties are more vigorous and hardy than are some of the more prolific white varieties.

(6) The best yields are secured from dent varieties, which require about 160 days for maturing and average nearly two ears per stalk. The ears should be of good size, have small cobs well filled at each end, and should hang downward when ripe.

(7) Nothing is gained by planting before the ground is sufficiently warm and dry to promote immediate growth. Early plantings should not be covered so deep as late plantings.

(8) Cultivation should be shallow and frequent, and the surface of the ground should be kept as nearly level and smooth as possible.

(9) When other hay can be saved readily and the cornfields can be pastured immediately after the crop is gathered it is not usually profitable to cut the stalks for fodder.

(10) Corn which is to be stored for some time should be treated with bisulphid of carbon to destroy insects.

(11) Seed should always be selected in the field by taking the best ears from the best stalks.

FARMERS' BULLETINS.

These bulletins are sent free of charge to any address upon application to the Secretary of Agriculture, Washington, D. C. Only the following are available for distribution:

No. 15. Some Destructive Potato Diseases: What They Are and How to Prevent Them. No. 16. Leguminous Plants for Green Manuring and for Feeding. No. 18. Forage Plants for the South. No. 19. Important Insecticides: Directions for their Preparation and Use. No. 21. Barnyard Manure. No. 22. Feeding Farm Animals. No. 23. Foods: Nutritive Value and Cost. No. 24. Hog Cholera and Swine Plague. No. 25. Peanuts: Culture and Uses. No. 26. Sweet Potatoes: Culture and Uses. No. 27. Flax for Seed and Fiber. No. 28. Weeds; and How to Kill Them. No. 29. Souring of Milk and Other Changes in Milk Products. No. 30. Grape Diseases on the Pacific Coast. No. 31. Alfalfa, or Lucern. No. 32. Silos and Silage. No. 33. Peach Growing for Market. No. 34. Meats: Composition and Cooking. No. 35. Potato Culture. No. 36. Cotton Seed and Its Products. No. 37. Kafir Corn: Characteristics, Culture, and Uses. No. 38. Spraying for Fruit Diseases. No. 39. Onion Culture. No. 40. Farm Drainage. No. 41. Fowls: Care and Feeding. No. 42. Facts About Milk. No. 43. Sewage Disposal on the Farm. No. 44. Commercial Fertilizers. No. 45. Some Insects Injurious to Stored Grain. No. 46. Irrigation in Humid Climates. No. 47. Insects Affecting the Cotton Plant. No. 48. The Manuring of Cotton. No. 49. Sheep Feeding. No. 50. Sorghum as a Forage Crop. No. 51. Standard Varieties of Chickens. No. 52. The Sugar Beet. No. 53. How to Grow Mushrooms. No. 54. Some Common Birds in Their Relation to Agriculture. No. 55. The Dairy Herd: Its Formation and Management. No. 56. Experiment Station Work—I. No. 57. Butter Making on the Farm. No. 58. The Soy Bean as a Forage Crop. No. 59. Bee Keeping. No. 60. Methods of Curing Tobacco. No. 61. Asparagus Culture. No. 62. Marketing Farm Produce. No. 63. Care of Milk on the Farm. No. 64. Ducks and Geese. No. 65. Experiment Station Work—II. No. 66. Meadows and Pastures. No. 67. Forestry for Farmers. No. 68. The Black Rot of the Cabbage. No. 69. Experiment Station Work—III. No. 70. The Principal Insect Enemies of the Grape. No. 71. Some Essentials of Beef Production. No. 72. Cattle Ranges of the Southwest. No. 73. Experiment Station Work—IV. No. 74. Milk as Food. No. 75. The Grain Smuts. No. 76. Tomato Growing. No. 77. The Liming of Soils. No. 78. Experiment Station Work—V. No. 79. Experiment Station Work—VI. No. 80. The Peach Twig-borer: An Important Enemy of Stone Fruits. No. 81. Corn Culture in the South. No. 82. The Culture of Tobacco. No. 83. Tobacco Soils. No. 84. Experiment Station Work—VII. No. 85. Fish as Food. No. 86. Thirty Poisonous Plants. No. 87. Experiment Station Work—VIII. No. 88. Alkali Lands. No. 89. Cowpeas. No. 90. The Manufacture of Sorghum Sirup. No. 91. Potato Diseases and Their Treatment. No. 92. Experiment Station Work—IX. No. 93. Sugar as Food. No. 94. The Vegetable Garden. No. 95. Good Roads for Farmers. No. 96. Raising Sheep for Mutton. No. 97. Experiment Station Work—X. No. 98. Suggestions to Southern Farmers. No. 99. Three Insect Enemies of Shade Trees. No. 100. Hog Raising in the South. No. 101. Millets. No. 102. Southern Forage Plants. No. 103. Experiment Station Work—XI. No. 104. Notes on Frost. No. 105. Experiment Station Work—XII. No. 106. Breeds of Dairy Cattle. No. 107. Experiment Station Work—XIII. No. 108. Saltbushes. No. 109. Farmers' Reading Courses. No. 110. Rice Culture in the United States. No. 111. Farmer's Interest in Good Seed. No. 112. Bread and Bread Making. No. 113. The Apple and How to Grow It. No. 114. Experiment Station Work—XIV. No. 115. Hop Culture in California. No. 116. Irrigation in Fruit Growing. No. 117. Sheep, Hogs, and Horses in the Northwest. No. 118. Grape Growing in the South. No. 119. Experiment Station Work—XV. No. 120. Insects Affecting Tobacco. No. 121. Beans, Peas, and Other Legumes as Food. No. 122. Experiment Station Work—XVI. No. 123. Red Clover Seed: Information for Purchasers. No. 124. Experiment Station Work—XVII. No. 125. Protection of Food Products from Injurious Temperatures. No. 126. Practical Suggestions for Farm Buildings. No. 127. Important Insecticides. No. 128. Eggs and Their Uses as Food. No. 129. Sweet Potatoes. No. 130. The Mexican Cotton Boll Weevil. No. 131. Household Test for Detection of Oleomargarine and Renovated Butter. No. 132. Insect Enemies of Growing Wheat. No. 133. Experiment Station Work—XVIII. No. 134. Tree Planting in Rural School Grounds. No. 135. Sorghum Sirup Manufacture. No. 136. Grape Culture in the North. No. 137. The Angora Goat. No. 138. Irrigation in Field and Garden.

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U. S. DEPARTMENT OF AGRICULTURE.

FARMERS' BULLETIN No. 82.

THE CULTURE OF TOBACCO.

BY

OTTO CARL BUTTERWECK.

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LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
DIVISION OF SOILS,
Washington, D. C., June 18, 1898.

SIR: I have the honor to transmit herewith a paper on The Culture of Tobacco, prepared by Otto Carl Butterweck, of Brooksville, Fla. This paper was submitted in response to invitations sent out by the Secretary of Agriculture, and was selected from a lot of thirty papers submitted upon the same subject.

As other bulletins treating of the insect enemies and the diseases of tobacco and the whole subject of fertilization of tobacco are in course of preparation, a good deal of matter prepared by Mr. Butterweck upon these subjects has been omitted from the present bulletin.

I recommend that this be published as a Farmers' Bulletin.

Respectfully,

MILTON WHITNEY,
Chief of Division.

HON. JAMES WILSON,
Secretary of Agriculture.

CONTENTS.

Page.
Selecting the seed.. 5
How much seed to sow.. 5
The seed bed and how prepared in the different tobacco districts............. 6
  Burning the bed 7
  Preparation of the soil... 8
  Protection 9
Sowing the seed 9
Time of sowing seed 10
Planting... 13
  Watering 15
Cultivation 16
Fertilizers.. 16
Topping 17
Cutting 18
Saving seed.. 20
Insect pests... 22

THE CULTURE OF TOBACCO.

SELECTING THE SEED.

In the production of tobacco the proper selection of seed is one of the most important problems. Good methods, skill and experience in cultivation, careful worming, and care in the barn and after curing all amount to little if there has been any carelessness in selecting the seed.

As the different soils of the various States produce different types of tobacco, the prospective grower will have to learn from the experience of others and from the best literature he can obtain what variety of seed will likely yield the best product on the particular land to be planted. With this knowledge of what is wanted, too much care can not be exercised in obtaining the seed. It is advisable to obtain it from reliable seedsmen or from an intelligent grower rather than from a country druggist or grocery store.

Having procured the best seed for the locality and soil, the grower should maintain and improve the quality by proper selection of seed from his own crop or by the production of seed plants in other ways, as will be explained later. The production of tobacco seed requires careful attention because some varieties deteriorate while others improve in a given district. The Vuelta Abajo variety deteriorates in the States, while the Sumatra improves in flavor.

HOW MUCH SEED TO SOW.

Tobacco seeds are extremely small and an ounce of them contains from 300,000 to 400,000 seeds. A large percentage of these, however, will not sprout. Some of them are not fertile, and others have a very hard coating too resistant to moisture. On this subject Prof. S. W. Johnson, in How Crops Grow, says:

> Among the seeds of various plants—clover, for example—which under favorable circumstances mostly germinate within one or two weeks, may often be found a number which remain unchanged, sound and dry within for months and years, though constantly wet externally. The outer coat of these seeds is exceptionally thick, dense, and resistant to moisture. * * * In a collection of such seeds kept in water individuals sprout from time to time. In case of common sorrel it was found that 10 per cent of the seed germinated between the four hundredth and five hundredth day after putting in the sprouting apparatus.

After careful experiments it is pretty well established that not more than 75 per cent of the most carefully grown tobacco seed will germinate, while very much less than this will, under ordinary circumstances, be available for planting. Allowing, however, for the imperfections in the seed, and for the too deep and too shallow planting and for loss by accident, there ought to be at least 35,000 seeds or plants from an ounce of fresh tobacco seed. It must be remembered, however, that many of these plants will be weak and some of them will be retarded by the more vigorous plants. They will not therefore be of a uniform size and ready to transplant at the same time. As the grower usually plants the field at a single planting, he can not wait for the backward plants to grow. Experienced planters therefore usually sow at least three times the amount of seed that they expect to need in order to provide themselves with sufficient plants when the time comes for setting them out. A bed 3 by 50 feet, producing from 10,000 to 20,000 plants in the aggregate, can be used for sowing about one-third of an ounce of good fresh seed, but it is safer to sow three such beds for this number of plants. By having an abundance of plants one gets the additional advantage of having a large percentage of forward, thrifty plants.

The Cuban-grown seed is generally light and chaffy. In saving seed for sale the Cubans frequently allow not only the single spike to go to seed, but the suckers. They are careless also in mixing small and light pods containing many undeveloped seed as well as those which have been injured by insects. They do not winnow the dust and hulls from the seed as well as it is done in this country. It is therefore necessary in planting imported Cuban seed to sow three times as much as of domestic seed.

Before sowing the tobacco seed it is well to test the germinating power. Sometimes the seeds are put on a hot stove, when the sterile seeds will quietly char and the vital seeds will pop. This test can not be relied upon, but a real germinating test should be made. To do this, take 100 seeds carefully counted out, place them between two wet blotters, put these between two china plates so they will remain moist, and keep in a warm place at a temperature of from 70° to 80°. The blotting papers must be kept moist, but not wet. After ten days, separate the blotting papers and count the number of seeds that have sprouted. This will give the percentage of good seed, and will be a valuable guide as to the quantity of seed to sow.

THE SEED BED AND HOW PREPARED IN THE DIFFERENT TOBACCO DISTRICTS.

In selecting a site for a seed bed there are several things that need to be considered, viz, location, exposure, protection from frosts, insects, and parasitic diseases.

A southern exposure is always best, a southeastern exposure next, then a southwestern, then a western, and lastly a northern or northeastern. Where possible it is advisable to locate the seed bed near a pond, lake, running brook, or river because of the moisture and greater uniformity of temperature in such a location. At the same time there is often some danger of frosts in such a locality, and in the Northern States it is necessary for this reason to make the beds on the high, warm land and supply the moisture artificially by means of watering pots.

It is best, where possible, to make the bed upon new land. There is less danger from larvæ, insects, and weed and grass seed. As damp locations are more subject to parasitic and fungous diseases, many growers prefer to make their beds for this reason on high, dry, warm soil near the house and keep it damp by frequent sprinkling. In the Southern States, as in Cuba, an open space in the woods where the midday sun shines has always been a favorite location for a seed bed because of the protection the trees afford from the cold winds and the excessive drying out of the plants and soil. The conditions are more uniform and there is less danger from frosts and insect ravages. In the Northern States the seed bed is usually made near the dwelling in the form of a cold frame with muslin over it as a protection from insects and excessive evaporation.

With the exception of the perique tobacco district in Louisiana, seed beds are burned by the most experienced growers in all localities. In the Northern States where the ground uniformly freezes to any considerable depth, the burning may be done late in the fall or in some mild spell in midwinter. In the South the land is burned over just before the seeds are sown. It is necessary to do this unless the ground has been kept thoroughly clean for several years, or unless it has been mulched the preceding year, as the ground will be so foul with weeds and grass that the young tobacco plants stand little show of surviving in the struggle for existence when vegetation begins. This burning is also a protection from grubs and insects. The object of burning is to make the ground hot enough to actually destroy the seeds of grass and weeds and to destroy the larvæ and young noxious insects which may damage the young plants.

BURNING THE BED.

Minute directions are often given about burning a seed bed, as though it were a difficult thing to do. Anyone, however, can readily burn a seed bed. Where any clearing has been done the site of a burned log heap is as good a place for a bed as can be selected.

The material at hand must determine the way in which the bed should be burned. If the material recently cleared from the land is brush, spread it in a thin layer over the ground and burn it, adding more from time to time so as to keep the heat near the ground. It is not economical to have a high pile, as much of the heat will not then be effective on the soil. If the material at hand consists of rails and logs lay down a few rails or poles several feet apart to keep the burning wood off the ground and to admit air. Lay the wood on these poles from one to several inches apart according to circumstances. Start the fire on the leeward side so that it will burn slowly. A steady slow fire will make a better burn than a flashy quick one. The moisture in the soil to a depth of several inches must be converted into steam. This steam in forming uses up a quantity of heat. The fire must be continued long enough to steam the ground thoroughly to a depth of several inches. The upper layer of the soil to a depth of one-tenth of an inch or so will have the appearance of a burned brick when the operation has gone far enough.

PREPARATION OF THE SOIL.

After the bed has been burned and has had time to cool it should be broken with a hoe or other suitable implement to a depth of about 2 inches and the surface thoroughly pulverized. The roots and trash must be carefully raked off with a garden rake and the surface left in a level, loose, porous condition. A pound of some good commercial fertilizer or guano should be applied to each 3 square yards and thoroughly raked in.

The surface of the bed must be thoroughly pulverized and loose, so as to permit the delicate plants to grow readily, which they will not do in a lumpy soil. It also affords a good medium for the rootlets of the young tobacco plants. The bed, however, should not be worked deeply, as this would tend to prevent the moisture from rising from below and might bring to the surface seeds of grass and weeds which had been buried deeply and escaped the heat. If there is danger of washing by heavy rains it is necessary to protect the bed by shallow ditches on the sides subject to the flow of water, both to prevent the sides from being washed away or from being covered up by a deposit of sand and clay.

In the perique tobacco district of Louisiana, according to Mr. Killibrew, the making of seed beds is unlike the same work in other States. It begins in October, when cow manure is applied to a depth of 6 inches to a chosen spot in the forest and turned under with a spade. In December the bed is worked but not burned, and ditches are cut through to secure drainage. The soil is mostly humus and the beds can not, therefore, be burned.

In ordinary seasons the seed will be up in two weeks after planting. After the first leaves appear the plants seem to grow very slowly, although the roots are developing then quite rapidly. In two weeks after the plants have appeared they become more vigorous and begin to grow rapidly, especially if watered with weak liquid manures. In from six weeks to two months after the seed is sown the plants are ready for transplanting to the field.

Growers usually make it a rule to plant seed beds a week or ten days apart, as a protection against unexpected cold and other causes of loss.

When a bed is killed out with the cold it is immediately resown. When the plants are too thick in a bed they should be immediately thinned to allow space for a good root development. Each plant should be allowed at least a square inch of space for the roots to develop.

PROTECTION.

In any locality it is well to have the bed inclosed with a cold frame and covered with plant muslin. For this purpose, after burning the seed bed and before sowing the seed, inclose the bed with a frame made of 1-inch plank, 8 or 10 inches wide, placed on edge, and nailed at the corners with diagonal strips of 1 by 3 inch plank, countersunk at the corners and securely nailed for additional safety. If there are no planks available, take two poles, 4 or 5 inches in diameter, and place one on top of the other, instead of the plank. The bed may be of any desired dimensions, but it is well to have it not over 3 feet wide in order that all parts of it may be reached from either side. If there is any slope to the land a ditch should be dug on the upper side of the bed to prevent washing and the earth thrown in against the side of the bed for additional protection against washing and cold winds.

SOWING THE SEED.

As the impervious nature of the seed coat is the reason for many of the seeds not sprouting, a very simple method can be employed to obviate this trouble. Spread a newspaper on a table and lay a sheet of the finest emery paper on it. Pour a few seeds on this and with another piece of emery paper rub the seed gently. This will scratch their thick envelopes and enable them to absorb water. It is well to place the seed in a damp place for a day or two before scratching, for if they are very dry when scratched they are apt to be hulled when treated in this way. After scratching the coat, place the seed in a bowl and pour just enough water on them to cover the seed. Let them stand for forty-eight hours, by which time they will have absorbed all the water. Then mix the seed in the proportion of a quarter of an ounce of seed to 2 quarts of wood ashes, corn meal, or sterile earth and sow them carefully and evenly over the bed. Do not soak the seed unless you water in sowing. Meal or ashes are preferred to earth, because it is easy to see from the color if the sowing has been evenly done. The seed should be sowed when the wind is quiet. The seed may be sown by the thumb and fingers, or like grain, except that the hand must be held close to the bed and the sweep of the hand limited. After sowing the seed, sweep the bed over carefully with a brush, broom, or small switch, simply disturbing the surface of the bed and being careful not to bury the seed too deep.

Professor Storer, in his book entitled "Agriculture," says:

> As to the methods of sowing grass seed, experience teaches very emphatically that the seed should not be buried deeply in the earth, as they do not contain a sufficient

supply of nourishment to carry the sprout through a considerable layer of earth, and there is great danger of losing them if they are deeply covered. It is true, in general, that wherever seeds can be kept properly moistened they should not be deeply buried, and this both because the seed need air and because of the risk of placing too many impediments in the way of the young shoot. The distance through which the young shoot must pass in order to get above ground should be as short as possible, in order that the store of nourishment in the seed may not be wholly exhausted in the struggle with the layer of earth above the seed. Some of this store of nourishment is wanted to establish the plant firmly after it has reached the air. With timothy seed, for example, a German experimenter, Jenson, found that less than half the number of seed sown an inch deep came up either in loam or sand, while the whole of the seed grew that was sown 0.06 of an inch deep.

The importance, then, of covering the tobacco seed very little will be appreciated when it is remembered that tobacco seed is very much smaller than timothy seed.

After the seed has been sown and brushed in, it should be thoroughly sprinkled to firm the earth. This is the best practice. It may be firmed by carefully tamping with a spade or hoe, or by laying down a board and standing upon it, turning the board over and repeating until the whole bed has been gone over. It may be tamped with square boards, 8 by 10 inches, secured to the feet with straps. The writer is convinced, however, that the firming is best done by simply thoroughly sprinkling and keeping the bed continuously moist. The sprinkling should be repeated twice a week, or even oftener if necessary, and daily in very dry weather. The beds should be kept covered with canvas or cloth fastened on the side of the frame by means of headless wire nails driven in such a manner as to hold the cloth; or the covering may be fastened to small poles or inch strips a few inches longer than the length of the bed and placed 2 feet apart with the cloth fastened to them. Such a covering can be readily rolled up and stored away, and will last several seasons. A bed so covered will be protected from the depredations of insects of all kinds—a constant source of annoyance and loss in open beds. Moisture, also, will be conserved, and both the humidity and temperature of the air will be more uniform. A week or two before transplanting the covering should be removed about one-half hour after sunrise for an hour or two and the time of exposure increased from day to day until two or three days before planting, when the covering should be left off altogether to harden the plants and give them the necessary vigor to stand the shock of transplanting.

TIME OF SOWING SEED.

There seems to be a general rule for sowing the seed in each State with reference to the frosts which are likely to occur in the spring. The following table, furnished by the Weather Bureau, will be a basis for a more intelligent rule for sowing the seed. Seed beds should be planted from six weeks to two months, according to the variety of the seed, before the latest date at which killing frost has occurred in the locality. This is for domestic seed. For imported Cuban and Sumatra seed a later date should be selected. Imported Cuban seed should be planted a month later and imported Sumatra six weeks later than acclimated seed. Very vigorous varieties of tobacco will grow large enough to transplant in six weeks; other varieties will take from eight to ten weeks from the time of sowing the seed.

The following table gives the average and latest dates at which killing frosts occur in the spring, as furnished by the Weather Bureau:

Average and actual date of last killing frost in the spring and earliest killing frost in the fall.

[From records of the United States Weather Bureau.]

State and locality.	Spring.		Fall.
	Average.	Last.	Earliest.
Alabama:			
Mobile	Feb. 24	Apr. 6	Nov. 2
Montgomery	Mar. 10	do	Oct. 21
Arkansas:			
Little Rock	Mar. 21	Apr. 14	Oct. 8
Fort Smith	Mar. 22	Apr. 6	Oct. 7
Colorado:			
Denver	May 25	June 6	Sept. 10
Connecticut:			
New Haven	May 30	May 30	Sept. 15
District of Columbia:			
Washington	Apr. 4	Apr. 29	Oct. 4
Florida:			
Cedar Key	Feb. 4	Mar. 12	Nov. 25
Jacksonville	Feb. 24	Mar. 27	Nov. 12
Pensacola	Mar. 7	Apr. 6	Do.
Georgia:			
Atlanta	Mar. 25	May 21	Oct. 16
Augusta	Mar. 17	Apr. 5	Oct. 8
Savannah	Mar. 1	do	Nov. 2
Illinois:			
Cairo	Mar. 31	May 8	Oct. 2
Chicago	Apr. 23	May 25	Sept. 27
Springfield	Apr. 16	do	Sept. 13
Indiana:			
Indianapolis	Apr. 17	May 21	Sept. 26
Iowa:			
Davenport	Apr. 25	May 22	Sept. 13
Des Moines	Apr. 24	May 31	Sept. 12
Dubuque	Apr. 27	May 23	Sept. 5
Keokuk	Apr. 10	May 2	Sept. 18
Kansas:			
Dodge City	Apr. 22	May 23	Sept. 23
Leavenworth	Apr. 6	May 21	Sept. 13
Kentucky:			
Louisville	Apr. 8	May 15	Sept. 30
Louisiana:			
New Orleans	Feb. 2	Mar. 27	Nov. 11
Shreveport	Feb. 26	Mar. 31	Oct. 13
Maine:			
Portsmouth	Apr. 14	May 5	Sept. 7
Maryland:			
Baltimore	Apr. 6	May 8	Oct. 6
Massachusetts:			
Boston	....	May 17	Sept. 30
Michigan:			
Alpena	May 10	June 29	Aug. 24
Detroit	May 2	May 28	Sept. 23
Escanaba	May 13	May 29	Sept. 1
Grand Haven	May 30	May 28	Aug. 21
Marquette	May 18	June 11	Aug. 22
Port Huron	May 2	June 6	Sept. 14
Minnesota:			
St. Paul	May 1	May 25	Sept. 1
Duluth	May 6	June 8	Sept. 13
Moorhead	May 18	June 5	Aug. 25
Mississippi:			
Vicksburg	Mar. 3	Apr. 22	Oct. 19
Missouri:			
St. Louis	Mar. 31	May 2	Oct. 14

Average and actual date of last killing frost in the spring and earliest killing frost in the fall—Continued.

[From records of the United States Weather Bureau.]

State and locality.	Spring.		Fall.
	Average.	Last.	Earliest.
Nebraska:			
Omaha	Apr. 15	....	Sept. 20
North Platte	May 1	....	Sept. 10
New Jersey:			
Atlantic City	Apr. 6	Apr. 29	Oct. 4
Cape May	....do ...	May 3	Oct. 29
New Mexico:			
Santa Fe	Apr. 22	May 22	Sept. 19
New York:			
Albany	Apr. 21	... do ...	Oct. 15
Buffalo	May 27	May 29	Sept. 21
New York	Apr. 14	Apr. 25	Oct. 15
Oswego	Apr. 26	May 20	Sept. 26
Rochester	May 8	....do ...	Do.
North Carolina:			
Charlotte	Apr. 1	May 8	Oct. 8
Hatteras	Feb. 27	Apr. 5	Nov. 22
Manteo	Mar. 14	Apr. 19	Oct. 16
Wilmington	Mar. 15	Apr. 20	Oct. 13
North Dakota:			
Bismarck	....	June 6	
St. Vincent	....	June 8	Aug. 4
Ohio:			
Cincinnati	Apr. 15	May 22	Sept. 30
Cleveland	Apr. 26	June 6	Sept. 24
Columbus	Apr. 18	May 17	Sept. 29
Sandusky	Apr. 9	May 23	Oct. 8
Toledo	Apr. 24	....do ...	Sept. 9
Oklahoma:			
Fort Sill	Mar. 15	Apr. 13	Oct. 1
Pennsylvania:			
Erie	Apr. 25	May 29	Sept. 16
Philadelphia	Apr. 5	Apr. 29	Oct. 2
Pittsburg	Apr. 27	May 22	Sept. 25
South Carolina:			
Charleston	Feb. 24	Apr. 2	Nov. 8
South Dakota:			
Deadwood	May 11	May 31	Sept. 7
Huron	May 14	June 22	Sept. 3
Yankton	Apr. 28	May 23	Sept. 13
Tennessee:			
Chattanooga	Mar. 23	Apr. 24	Sept. 30
Knoxville	Apr. 6	Apr. 25	Oct. 8
Memphis	Mar. 24	Apr. 21	Oct. 2
Nashville	Mar. 31	May 24	Oct. 8
Texas:			
Abilene	Mar. 14	Mar. 29	Oct. 22
Brownsville	Jan. 24	Mar. 1	Dec. 5
El Paso	Mar. 27	Apr. 22	Oct. 24
Galveston	Feb. 2	Mar. 18	Nov. 18
Palestine	....	Mar. 30	Nov. 10
Virginia:			
Lynchburg	Apr. 11	May 7	Oct. 3
Norfolk	Mar. 26	Apr. 20	Oct. 10
Wisconsin:			
La Crosse	May 1	May 23	Sept. 21
Milwaukee	Apr. 30	May 28	Sept. 17

Transplanting should be done as soon as possible after the date on which the last killing frost has occurred in the locality and should be completed within a month. It is frequently advisable to plant earlier than the date of the last killing frost and take the chance of the crop being caught. This, however, should be an exception. Early planting, to be sure, saves much labor in worming, and where air curing is practiced the benefit of the warm weather for the barn curing is quite an advantage. On the other hand, many prefer to plant as late as the season permits, because the warm sun of summer is believed to produce a sweeter product.

As a rule, early planting secures the benefit of the winter and spring rains and secures comparative freedom from insects, with the exception of the cut-worm. Where the transplanting is done late in the season there is more danger from drought and a greater risk of obtaining a poor stand. Of course where irrigation is practiced tobacco can be planted at a later date, provided it will mature during the growing season. Generally speaking, in localities south of the twenty-eighth degree of latitude, transplanting is done in February and March; in Louisiana from March 15 to April 15; Tennessee, May 1 to 20; Kentucky, about May 20; eastern Georgia, about April 10; western Georgia, May 1; South Carolina, April 10; North Carolina, May 1; Virginia, May 10; Pennsylvania, New York, New England, and Wisconsin, June 1 to 20.

It will be seen by comparing these dates with the schedule of the latest killing frosts that have occurred in their respective districts that experience has demonstrated that the best time to transplant tobacco plants is as early as possible after the date of the last killing frost that has occurred in the locality.

Before leaving this subject it will be well to call attention to the information in the third column of the table just given, which gives the date of the earliest autumn frost in the several tobacco seasons and marks what should be the end of the tobacco-growing season. Tobacco is very easily injured by frosts and it should be housed by the time the first killing frost is liable to occur in the autumn. It is easy, therefore, to calculate from this table the season in which the crop has to develop and mature. It must be remembered, however, that the occurrence of the first killing frost of the autumn varies considerably from year to year, and the average date is from one to four weeks later than the earliest date in most of the localities given in the table.

PLANTING.

The field selected for the tobacco should be plowed in the fall. This will tend to bring it into good tilth and will help to destroy larvæ of all kinds which may be destructive to the crop when it is young. In localities where the ground freezes it is well to plow in the fall for the purpose of destroying the cutworms. At the fall plowing it is well also to apply all rough manures which need time for rotting. In the spring the land is plowed again as early as possible, and the fertilizers are then applied and harrowed in. Two or three weeks before planting the land is again harrowed and laid off in rows either by throwing a furrow each way with a turning plow or with a ridger. The distance apart varies somewhat in the different localities, but a general rule is from 3 to 3½ feet apart each way. Sometimes the land is checked 3 by 4 feet, in order that the cultivation may be continued longer. In this case, if in the North, the wide furrows should run north and south for additional sunlight for the crop. With Sumatra tobacco, as grown in the South, 4 feet are allowed between the rows.

In the Northern States sunlight is sought after, while in Florida and Cuba shade is desired. Tobacco raised in an orange grove in Cuba always brings a better price than tobacco raised in the open field. In Florida open lattice sheds, with strips 3 inches wide and 3 inches apart overhead, are provided to shade the tobacco field. This method is growing in popularity.

For the smaller and finer varieties of manufacturing tobacco the checks may be 3 feet or 3 feet 3 inches square. In Sumatra, where the coolie does all the labor by hand, the rows are made 2 feet apart, and the plants stand 2 feet apart in the row. In Cuba and in southern Florida, where hand cultivation is still largely practiced, the rows are made 2 feet 6 inches apart, and the plants are set from 12 to 18 inches apart in the row, according to the strength of the soil and the amount of guano applied. Such close planting as this could not, of course, be adopted where horse cultivation is practiced, as in the Northern States.

The plants are set out when they are from 4 to 6 inches high in the seed bed. This is an invariable rule in all the tobacco districts of this country; but in Cuba they are allowed to grow much larger, even as much as 8 or 10 inches high. In drawing the plants the seed bed is thoroughly watered, so that it will be loose and will not tear the roots much in drawing the plants. It is also advisable to have as much of the soil adhere to the roots when taken up as possible. The drawing should be done in the early morning while the dew is on the plants, as the leaves are less liable to be injured. The plant should be grasped in one hand between the thumb and finger and gently lifted by means of a fork or small pointed stick to prevent as much as possible injury to the stem and roots and to bring up some of the dirt adhering to the roots. The plants are then put in baskets or small boxes, the roots together. The package is then covered with a damp cloth and placed in a shady, cool place until it is time to set out the plants.

In the early spring, especially when the day is cloudy and damp just after a rain, plants may be set out at any time in the day. Later in the season, however, as the air becomes drier and the temperature higher, plants are usually set out after noon. The later the season the later the time of setting out. Also the more southern the locality or the higher the temperature the later in the day the plants should be set out.

There are two methods of planting, either by hand or by the use of a planter. In hand planting the plants are dropped at regular intervals, usually by boys, girls, or women, while another hand follows with a dibble made of a round stick 1¼ inches in diameter and 10 inches long. With this he makes a hole into which he inserts the roots of the plant, holding the plant firmly with the leaves between the thumb and finger. The dirt is then pressed around the roots with the dibble to firm the soil, and then loose earth is brought up around the plant and the whole surface left in as loose a condition as possible. Sometimes the holes are made with a staff—that is, a smooth, round stick about 1½ inches in diameter and 4 feet long, sharpened at one end. A hand takes the staff and makes the holes with a brisk jab the desired distance apart as he walks along; another follows with a basket of plants, the plants being dropped near the holes; another follows and sets the plants in the holes. The plants should be so firmly imbedded that they can not readily be pulled up by pulling on the top of one of the leaves.

WATERING.

If the soil is damp when the plants are set they will grow without water. If, however, the soil is dry when the plants are put out watering will have to be done immediately before planting. To do this a hand precedes the planter with a pail of water and a dipper and fills the holes with water just before the plant is set in. If the season continues dry the plants may need watering until they establish themselves, which is usually about a week from the time of setting out. In this case it is better to make a hole near the plant with the dibble and put the water in that and cover it over with loose dry soil to prevent evaporation than to apply the water directly to the surface. Where possible it is, of course, very much better and very much cheaper to wait for the spring rains to moisten the ground and get it in order for planting.

On large plantations in Cuba no holes are made to set plants in. They "bust out the middle of the row" with a scooter or shovel and set plants in the furrow. The plants are set so that the bud will come just above the level of the field. The furrows are freshly made as the planting proceeds, so that the soil shall not dry out too much for planting. The plants are usually longer than in this country, and if they are of extra length they are planted in a sloping position or are bent in the furrow so that the bud only will be above the level of the field. After planting the rows are leveled with a hoe. Replanting is done where necessary, but otherwise the soil is not disturbed for about two weeks, or until the plants become established. After that the field is continuously worked and is kept like a garden. The Cubans claim that with a setting of larger plants less loss occurs than with smaller ones. The writer has tried this furrow system and has no hesitation in recommending it to tobacco planters. It is more speedy to set the plants in rows and there is no reason why it should not be practiced in check fields.

The method of transplanting with machines is now very generally practiced in the Northern cigar-tobacco States. There are a number of machines designed for this purpose upon the market. The machine is usually drawn by two horses and carries the driver and two other persons to throw in the plants. The machine waters the holes uniformly before planting, sets the plant, and firms the earth uniformly and firmly around it. It is claimed that machine-set plants usually grow off better than hand-set ones and a better stand is obtained. Where the transplanter is used the field must be in excellent tilth and free from stumps, rocks, and litter. By its use a man and two boys can set from 2 to 6 acres per day, and as the soil is watered immediately before setting it is not necessary to wait for a wet season.

CULTIVATION.

A tobacco field should be kept clean and in good tilth, both to promote the growth of the plant and, by removing grass, weeds, and trash, to lessen the harbors for insects of all kinds. In ten days or two weeks after the plants have been set out, hoe between them, removing the dry dirt and drawing fresh moist earth to them. They should then be cultivated with a shallow instrument, such as a cultivator or a sweep, throwing a little earth to the plant. The cultivation should be shallow. Do not cut or disturb the roots of the tobacco plant, as it checks its growth and tends to make a fibrous, woody leaf. A rapid growth from the time of setting until the plant matures gives a finer textured leaf than a slow growth. Still, for some varieties of tobacco and for certain purposes it is not desired to have a fine texture of leaf. No rigid rule can be laid down as to the frequency of cultivation. Judgment must be used in this as in other matters of farm practice. As a rule, fields should be cultivated after every rain, as soon as the soil is in condition to work. The surface should be stirred after the rain, both to admit air and to prevent excessive evaporation.

When the plants get of large size and begin to throw out buds they will be too large for horse cultivation. The field should then be kept clean from weeds and grass with a hoe. Dr. Goessman, of the experiment station at Amherst, Mass., says "the timely shallow use of the cultivator or the hoe for the removal of weeds favors a uniform progress and growth. The careless use of the cultivator or hoe invariably checks more or less the growth of the plants and modifies more or less strikingly the general character." In cultivating, always work the soil to the plant. It is better to pull up a few weeds and bunches of grass near the plant than to use a tool, because of the danger of injuring the roots.

FERTILIZERS.

In fertilizing the tobacco plant there is need to consider both the yield of the crop as a whole and the effect of certain fertilizers upon the quality of the finished leaf. There are certain substances which can not be used without injuriously affecting the burning qualities of the leaf. Chlorine, which is contained in common salt, muriate of potash, kainit, and generally in the lower and cheaper forms of potash salts, is decidedly injurious to the burning qualities of tobacco. Sulphate of potash, when used in excess, is generally believed to be injurious to the burning qualities of the cigar leaf. Excess of phosphoric acid is injurious, as it affects the color of the ash. According to Nessler's observations, the more phosphoric acid there is in a soil the more of it is taken up by the tobacco plant. Excess of nitrogen, especially that in the form of raw animal fertilizers and fresh animal manure, makes a coarse, thick leaf which is unfavorable for the wrapper types, but is quite favorable to some of the manufacturing and export types.

As a rule, care must be taken in the production of cigar wrapper leaf and in the bright yellow leaf of Virginia and North Carolina to use only moderate quantities of stable manure or animal nitrogenous manures of any kind, as it is not desired that the leaf should be thick and coarse. With the heavy export types great quantities of these manures may be used to advantage. Large quantities of mineral manures are used in the production of both the wrapper leaf for cigars and the bright yellow tobacco, as these are both grown on very poor sandy soils which depend mainly for their food supply upon the minerals applied.

Dr. Goessman summarizes the results of the field experiments with the cigar tobacco in Massachusetts in Bulletin No. 47 of the Massachusetts Experiment Station, as follows:

> Cotton-seed meal and castor pumice have proved quite good sources of nitrogen for the successful raising of tobacco when used in connection with nitrate of soda or potash sufficient to furnish one-fourth of the nitrogen called for by the crop. Cotton-seed hull ashes and high-grade sulphate of potash have proved, in our observation, most valuable sources of potash for tobacco. Acid phosphate and phosphatic slag are used in preference to animal phosphates. The standard fertilizer, recommended by the station, was phosphate 3 per cent, nitrogen, 5 per cent, and potash, 15 per cent. There have been so many conflicting claims made as the result of careful experiments in different localities that it is evident that the nature of the soil, the character of the season, and other factors which are not known at present have so much influence that no precise statement can be made of the best fertilizers for tobacco.

From 200 pounds to a ton of commercial fertilizers are commonly applied per acre to the tobacco crop. Sometimes as much as 2 tons are used where a high-grade wrapper leaf or thin, bright tobacco can be produced. The fertilizer may be either broadcasted or drilled in the row just before the plants are set out. Sometimes the fertilizer is applied in two or three applications during the season.

TOPPING.

The objective point in the life of a plant is the production of seed for the perpetuation of the species. When the seed head forms and develops, the nourishment is gradually transferred from the leaves and used for the formation and production of seed. In a plant like tobacco, which is valued for the quality of the leaf, it is necessary to remove the seed head as it forms, in order that the nutritive substance may remain in the leaf. When the bud is removed the plant throws out suckers at the junction of the leaves, and these also must be promptly removed or the leaf will lose part of the nutritive matter which has been stored up in it.

Just when is the proper time to top is a disputed question. It depends upon the variety of the plant, the vigor of growth, and the conditions of soil and climate, as well as upon the use for which the tobacco is intended. To retain the greatest amount of nutritive matter in the leaves and to induce a uniform ripening of the plant, the bloom bud should be removed as soon as it appears.

Just how much of the top should be removed in taking out the bud also depends upon the variety of tobacco and upon the strength and vitality of the plant. Strong, vigorous plants are topped high. When a good stand is obtained at planting, the plants will bud about the same time, but all the plants of a field will not be ready to top at the same time, and a great deal of judgment is required to know when to remove the bud. This judgment is based upon the vitality of the plant and for what purpose the leaves are to be grown. It is necessary, therefore, to go over the field several times to remove the buds, and after the first time the suckers are removed at the same time the buds are taken out. It must not be understood that suckering is not necessary before this time. Some plants send out suckers at an early period of their life, long before the bloom bud appears, and these suckers must be removed as they appear.

In the cigar-tobacco districts from 15 to 20 leaves are left on the plant. When the tobacco is intended mainly for cigar fillers a less number are left on, as it is desired to have the leaves stronger than where wrappers are produced. On the heavier types of manufacturing and export tobaccos from 10 to 12 leaves are left on. More are left on very vigorous plants than on delicate ones. Experienced toppers do not count the leaves, but use their judgment as to the ability of the plant to maintain a certain number which they think should be left on. The suckers have to be removed two or three times during the season.

In Cuba and in Florida a good, vigorous sucker is allowed to remain when the plant is cut, and this develops into what is called a sucker crop, which is somewhat inferior to the first crop, but is good for filler purposes.

CUTTING.

"The passage of the various constituents of a plant from one part of it to another, as the plant advances to maturity, is a capital fact common to all plants, and we see in fact that the oldest leaves gradually wither and die as they give up to the newer parts of the plant many of the matters that were contained in their cells. There comes a time when the plant ceases to draw food from the air and from the soil and devotes itself to the purpose of concentrating the nourishment that was previously scattered through all its parts." At this period the leaves begin to change color, light yellow spots appear upon them, and the leaf or plant is said to be ripe and ready to be cut. As the leaves ripen from the bottom upward, the rational system is to pick or prime the tobacco as the leaves ripen. This is done in the bright-tobacco district and to some extent in the cigar districts of Florida. In the other districts, including the cigar districts of the North and manufacturing and export tobacco districts, the plant is cut when the middle leaves are about ripe. If the plant is not fully matured at the time of cutting it is liable to cure dark, or if the weather happens to be dry or cold, so that it dries out quickly, it will cure green and be worthless.

The time when a plant is ripe and ready to be cut is a matter of judgment and experience. There is a slight change in the color of the leaf, perceptible in looking over a field of tobacco, which shows the experienced grower that it is ready to be cut. When the leaf is observed to change color from a rank green to a lighter shade of green, and yellow spots appear, it is a certain indication that the constituents of the leaf have performed their duty and are going back to the stalk to be carried to the upper leaves or to be used for other purposes in the economy of the plant.

Another test of this is to fold the leaf between the fingers, and if the leaf snaps or retains a crease where it was folded it is said to be ripe.

A plant that is topped low, with only 8 or 10 leaves, will mature more uniformly, of course, than one that is topped high, like the Sumatra, where 18 or 20 leaves are left on the plant.

Cutting or priming should not be done when dew or rain is on the plant, as it is liable to leave black spots on the cured leaf. In the South cutting is not done until afternoon in midsummer, as the midday sun is liable to sunburn the tobacco in a few moments.

Where priming is done the leaves are placed in baskets or shallow boxes to be carried to the drying sheds, where they are strung on twine or on wires. The leaves are put face to face and back to back, 30 to 50 to a string, according to the size of the leaf. The twine or wire is then stretched on a 4-foot lath with a slit about 2 inches long sawed in each end, and hung in its place in the barn. In harvesting plants they will not all be ready to be cut at the same time, and it is necessary to go over the field a number of times, and cut them only as they ripen.

Where the whole plant is cut it is allowed to wilt for several hours before being carried to the barn to prevent breaking the turgid leaves. Plants are cut and laid in rows on the ground to wilt, several rows being laid in one for convenience in handling. With the finer grades of cigar wrapper the plant is not allowed to lie on the ground directly, and in many localities the wilting is done after the plant is put on laths, upon which it is to be hung in the barn, and the laths supported on small trestles in the field or in racks arranged for the purpose. When sufficiently wilted the tobacco is hauled to the barn, either on racks made for the purpose or carefully piled on the wagon bed. In hanging the tobacco the butts are either pierced with an iron-pointed lath, or the stalk is split all the way up and the plants strung on the laths in this way. Before being hung up care should be taken to remove all worms and eggs from the leaves, as the latter are liable to hatch and the worms do great injury to the leaves while hanging in the barn. All the suckers should also be removed, or they will continue to grow and absorb the nourishment of the full-grown leaves.

In Cuba and southern Florida the plant is cut in sections in the field. The three top leaves, usually the finest wrappers, are cut in one section, the rest of the stalk is cut in sections of two each. Two rows are taken at a time, and the sections are assorted according to their grade and position on the plant. The field is gone over several times until all the ripe plants have been cut. Boys accompany the experts and receive the sections on their arms, the stems being turned alternately to prevent the loads from falling. When a turn has been received the boys slide the sections on to poles placed on forked stakes at convenient places in the field. These poles when full are carried to the barn. The Cubans use long poles, usually 13 feet in length. This system has the advantage of sorting the tobacco as it goes into the barn. As the curing progresses in the barn the leaves are separated more and more for a better circulation of air.

Cut tobacco must not be left exposed to the sun and wind, especially when lying on the ground in small piles. It must be hauled to the wilting sheds or barns as soon as the leaves are sufficiently wilted to avoid being broken in handling.

Where priming is practiced the leaves should be left to mature farther than where the entire stalk is cut, for while the stalk is hanging in the barn a translocation of the matters from the stalk to the leaves takes place and from the leaf to the stalk, and the leaf ages and matures, therefore, while hanging in the barn. When the leaf is once severed from the stalk, however, in the process of priming or cutting in sections, there is no opportunity for this transfer except to the very small portion of stalk which is left on the section.

SAVING SEED.

The grower should maintain and even improve the quality of his crop by a judicious selection of seed plants. To this end the field is gone over several times during the growing season and typical plants picked out possessing the greatest possible number of good points. After finally deciding upon the plants which should be saved for seed, these are allowed to grow to full maturity without removing the seed head when the rest of the field is topped. As the seeds of a plant are produced from the food material prepared in the leaves, the leaves should be left upon the seed plant until the seed is ripe. It isadvisable also to have plants close together in order that they may fertilize each other by the exchange of their pollen. Only the central spike of the plant should be left for seed, the suckers being removed as they develop in order that all the nourishment taken up by the plant should go into the central spike to make heavy seed.

The largest pods will contain the heaviest seed, and these should be selected for planting. "Hellreigel found that the weight of the seed sown had under some circumstances considerable influence on the yield of the crop, and that the young plants from the over ripe seed were decidedly the strongest and most vigorous, the others being smaller and feebler, very much in proportion as the seed from which they grew had been gathered earlier." The heavier seeds can be separated from the light by winnowing in a light wind or by screening. Seed plants of different varieties should be separated as far as possible to prevent crossing through the intervention of insects, air currents, etc. Exchanging and mixing seed of the same variety grown some miles distant is good practice, as it tends to make the seed and plants more vigorous.

A great deal of trouble arises in attempting to maintain a fair strain of tobacco seed on account of the facility with which cross fertilization occurs in the field. For this reason the recent experiments of Dr. Doroxie, editor of the "Hungarian Tobacco Gazette" of Budapest, mentioned by Killebrew and Myrick in "Tobacco Leaf," is of great interest. This gentleman "has propagated tobacco from slips, and claims that the leaves harvested from such propagated plants are finer and of higher quality than those of the mother plant."

The suckers from the plant are easily propagated in a suitable seed bed, just as slips of any of the ordinary flower plants, such as geranium or coleus. They can be readily grown to maturity in the field or in the hothouse, and the seeds so obtained will actually represent the parent without change from cross fertilization from other plants if care is taken.

It seems probable that by continuously raising seed from suckers instead of from seed, Havana or other superior kinds of tobacco can be acclimated in the Northern States and retain the qualities of the first year's crop, just as original qualities are retained by layering and grafting fruit.

Tobacco seed will retain its vitality for ten or twenty years, but it must be remembered that as a general rule all seeds begin to lose their vitality from the moment of ripeness. The process of deterioration with tobacco seed goes on, and on each succeeding year a less number of seeds will sprout until finally all lose their germinating power. In planting old seed they should be first tested and the quantity sown should be proportional to the vitality of the seed.

INSECT PESTS.

Trouble with insects begins from the moment the seed is sown and continues even after the tobacco is harvested and hung in the curing shed. Ants in the seed bed, cut-worms at the planting of the crop, and tobacco worms throughout the growing season of the plant have to be continuously sought for and destroyed. For cut-worms it is best to spread over the field before planting cabbage or turnip leaves, bunches of grass, or meal dipped in a solution of paris green, a tablespoonful of paris green to a bucket of water. Where the meal is used, one tablespoonful of paris green should be mixed with a gallon of meal or flour. Two such applications are recommended. After the plants are set it is also well to dust them with a mixture of paris green and meal.

There are several remedies proposed for the destruction of the tobacco worm, but the most satisfactory, although the most expensive method, is to search for them in the early morning and destroy them by hand. During the heat of the day they retire into sheltered places where it is not easy to find them. At the same time in looking for the worms, the eggs of the moth should be destroyed wherever seen on the leaves. These eggs are about the size of a tobacco seed and are nearly the color of the leaf itself, so that they are hard to find. Attempts have been made to catch the moth in various kinds of traps, and considerable relief has been secured thereby. The field should be gone over at least three times a week. It is especially desirable to destroy as completely as possible the earlier brood, so that there will not be so many later in the season when the main brood comes on.

FARMERS' BULLETINS.

These bulletins are sent free of charge to any address upon application to the Secretary of Agriculture, Washington, D. C. Only the following are available for distribution:

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U. S. DEPARTMENT OF AGRICULTURE

FARMERS' BULLETIN No. 83.

TOBACCO SOILS.

BY

MILTON WHITNEY,
CHIEF OF DIVISION OF SOILS.

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LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
DIVISION OF SOILS,
Washington, D. C., June 20, 1898.

SIR: I submit herewith a paper upon Tobacco Soils, which I recommend be published in the form of a Farmers' Bulletin. This is part of some preliminary work which has been done in the examination of the soils of the principal tobacco districts of the country, and is offered as a further addition to the number of bulletins upon tobacco which are being issued by the Department. The matter has been treated more at length in Bulletin No. 11 of this Division.

Respectfully,

MILTON WHITNEY,
Chief of Division.

Hon. JAMES WILSON,
Secretary of Agriculture.

CONTENTS.

Page.
Introduction 7
Climate and distribution of tobacco 8
Soils of the several districts 8
  Northern cigar tobacco 9
    The Connecticut Valley soils 10
    Pennsylvania cigar-tobacco lands 11
    Ohio cigar-tobacco lands 12
    Wisconsin tobacco soils 13
  Southern cigar tobacco 13
    Western Florida 13
    The Florida Peninsula 14
  Bright-tobacco lands 15
  Manufacturing-tobacco lands on the Atlantic 16
  White-Burley lands of Kentucky and Ohio 16
  Export-tobacco lands of Kentucky and Tennessee 17
  The water content of tobacco soils 20
    Water in the Northern cigar-tobacco soils 20
    Water in the Florida tobacco soils 21
    Water in the soils of the manufacturing and export tobacco districts. 21
    Control of the water supply of the soil 22

ILLUSTRATIONS.

FIG. 1.—Relative proportions of principal constituents of tobacco soils..... 19

TOBACCO SOILS.

INTRODUCTION.

The Department is constantly in receipt of letters asking for information and advice in regard to the growing of tobacco. For this reason a series of Farmers' Bulletins have been planned to cover different phases of the production and sale of tobacco. The main points of inquiry seem to be in regard to the kind of tobacco which should be grown and the method of curing the product.

Tobacco can be grown in nearly all parts of the country, even where wheat and corn can not be economically produced. The plant readily adapts itself to a great range of climatic conditions, will grow on nearly all kinds of soil, and has a comparatively short season of growth. But while it can be so universally grown, the flavor and quality of the leaf are greatly influenced by the conditions of climate and soil. The industry has been very highly specialized, and there is only demand now for tobacco possessing certain qualities adapted to certain specific purposes. A nondescript tobacco is not worth growing and should not be grown, as it lowers the price of really good types of tobacco, to the detriment alike of the grower and the consumer. As climate and soil conditions determine the character of the tobacco, it is important to understand what kinds of tobacco are in demand and what the climatic and soil conditions are which will most easily produce the qualities desired.

The principal kinds of tobacco grown in this country are the cigar types, for our domestic supply of cigars; the manufacturing types, for smoking and chewing, for our domestic use; the bright yellow tobacco, for cigarettes, smoking, and plug wrappers; White Burley, for smoking and chewing, both for domestic and export trade; and the export types proper, which are not suited to our domestic use, but which are mainly exported to foreign countries to be used both for cigar and manufacturing purposes.

In the ten years between 1879 and 1889 the acreage and yield of the cigar tobaccos were very considerably increased. The manufacturing and export districts can not be sharply separated, as both kinds of tobacco are frequently grown in the same district and the same kind is frequently used for both purposes. On the whole, there was a considerable decrease in the acreage and yield of these classes. With the bright yellow and burley tobaccos there was a large increase in both acreage and yield.

CLIMATE AND DISTRIBUTION OF TOBACCO.

It is a curious and interesting fact that tobacco suitable for our domestic cigars is raised in Sumatra, Cuba, and Florida, and then passing over our middle tobacco States, the cigar type is found again in Massachusetts, Connecticut, Pennsylvania, Ohio, Indiana, Illinois, and Wisconsin. The tobacco which we use only for chewing and smoking and which we send abroad is raised in the intervening States, the very best locality lying just below the latitude of southern Ohio.

It is surprising to find so little difference in the meteorological records for these several places during the crop season. There does not seem to be sufficient difference to explain the distribution of the different classes of tobacco, and yet this distribution is probably due mainly to climatic conditions.

One must still judge therefore, so far as the climate is concerned, mainly from the experience of others as to the class of tobacco to be raised, as the ordinary meteorological record will be of very little value in determining this point. The plant is far more sensitive to these meteorological conditions than are our instruments. Even in such a famous tobacco region as Cuba, tobacco of good quality can not be grown in the immediate vicinity of the ocean or in certain parts of the island even on what would otherwise be considered good tobacco lands. This has been the experience also in Sumatra and in our own country, but the influences are too subtle to be detected by our meteorological instruments.

Little, therefore, can be said at the present time in regard to the suitable climatic condition for tobacco of any particular type or quality.

SOILS OF THE SEVERAL DISTRICTS.

Under given climatic conditions the class and type of tobacco depend upon the character of the soil, especially on the physical character of the soil upon which it is grown, while the grade is dependent largely upon the cultivation and curing of the crop. Different types of tobacco are grown on widely differing soils all the way from the coarse, sandy lands of the pine barrens to the heavy clay limestone grass and wheat lands. The best soil for one kind of tobacco, therefore, may be almost worthless for the staple agricultural crops, while the best for another type of tobacco may be the richest and most productive soil of any that we have. It is particularly true of tobacco, to a greater extent perhaps than of any other crop, that the texture and physical properties of the soil influence the physiology of the plant to such an extent as to determine and control the distribution of the widely differing distinct types of tobacco. Soils producing a heavy shipping tobacco will not produce fine tobacco of any variety. Soils containing a large proportion of clay, or which for other reasons are very retentive of moisture, tend to produce large, heavy plants, which cure to a dark brown or red. A lighter sandy soil produces a plant having a thinner and more delicate leaf, which by proper treatment can be cured to a bright red mahogany or fine yellow color. So marked is this influence of soil upon the quality of the tobacco, that a fine, bright tobacco land may be separated by only a few feet from a heavier clay soil, which will produce only a heavy manufacturing or export leaf.

Manures and fertilizers tend always to increase the yield per acre, but where large quantities of nitrogen are added to the soil there is a tendency for the leaf to become thicker, heavier, and more gummy. In the case of the fine bright tobaccos or naturally thin-textured leaves this is apt to cause a marked deterioration in the character of the leaf; but with the heavier varieties this result is far from undesirable, because it merely increases the normal influences of the soil in making the leaf heavier, richer, and of more body. Considerable control can therefore be exercised upon the quality or grade of the leaf not only by judicious cultivation, but by proper fertilization.

NORTHERN CIGAR TOBACCO.

The grade of tobacco used to wrap a cigar for domestic purposes is quite different from that suitable for the filler. Theoretically the wrapper leaves are the best on the plant, the binders are second quality, while all the other leaves are used for filler purposes. The one plant, therefore, is supposed to produce the filler, binder, and wrapper for the complete cigar. As a matter of fact, this is seldom satisfactorily accomplished with the same plant except in Cuba and our Southern States. In the Northern tobacco States a plant which will produce a good wrapper leaf does not, as a rule, make a very good filler. Good domestic wrapper leaf is worth anywhere from four to twenty times as much per pound as a filler leaf, but as the filler leaf is grown on heavier soil, with closer planting, the yield per acre is much larger and, as the cultivation and treatment of the tobacco is less expensive, the return per acre, even at the low price per pound at which it is sold, can be made as profitable as the wrapper.

The Pennsylvania filler is seldom wrapped now with its own leaf. It is wrapped with either a Cuban, Sumatra, Connecticut Valley, or Wisconsin wrapper. A Connecticut wrapper seldom wraps its own leaves, but is used on a Cuban, Pennsylvania, Ohio, or Wisconsin filler. The present prevailing grade in the Connecticut Valley is a wrapper leaf, the second quality being used as a binder. In Pennsylvania at the present time the quality is a filler leaf, except on the river lands, where a light, thin-textured leaf is produced, which makes wrappers of a superior quality. The New York lands produce a good type of wrapper, and the crop at present is mainly a wrapper and binder grade. The Ohio tobacco is essentially a filler, and is covered with a Cuban, Sumatra, Connecticut Valley, or Wisconsin wrapper. The tobacco lands of Wisconsin appear to be nearly an average of the other States, and to produce in nearly equal excellence a wrapper and a filler leaf. It is commonly called a binder State.

THE CONNECTICUT VALLEY SOILS.

The tobacco soils of the Connecticut Valley are confined at present to the light, alluvial, sandy terraces and plains bordering the Connecticut River from northern Massachusetts down to within a few miles of the Sound. These soils are the general type of the early truck soils of the Atlantic coast. As a rule the lighter the texture—that is, the less clay they contain—the thinner the texture of the tobacco leaf and the more elastic, pliable, and better the wrapper it will make. The yield per acre, however, on these very light soils is very small, and the care necessary to keep the plant growing and to protect it from the occasional drought is expensive; so that there is a limit of profitable production. On these light soils the plant must be kept growing at all hazards; for if the growth is retarded by too great a deficiency of water at any time, the plant will be small and the leaves thick and harsh. With continuous and rapid growth, such as is secured on these soils in favorable seasons, the leaf is of very thin texture, silky, pliable, light-colored, and admirably adapted for a cigar wrapper. Unquestionably some form of irrigation could be profitably adopted on these soils. It is the experience in Florida that if the plant can be kept growing by frequent rains or by judicious irrigation, the maturity of the crop can be greatly hastened; so that the growing season is only about half as long as it would be under unfavorable weather conditions. Every possible means should be taken to secure a continuous growth, and any check, however slight it may seem, must be regarded as a positive injury to the quality of the product if it is to be used as a wrapper leaf. The wrapper should have little body and but little flavor.

The binder is a low-grade wrapper which, from its quality or appearance or both, is not suitable for the outside covering of the cigar.

The filler leaf, being worth much less per pound than the wrapper, is too often neglected in this country, and when cured is but little better than dried leaves or has a very rank, strong flavor. This is a very great mistake, as the filler, forming the main bulk of the cigar, should give it character and flavor. Too much care and attention could not be given to the growing and fermenting of the filler leaf, were it not for the fact that the market demands a good-looking cigar above all else. The quality is a very much smaller factor in determining the market value. The filler should always be a leaf of good body and much stronger and richer in its flavor than the present type of wrapper. The rich, heavy clay soils of Pennsylvania and Ohio are admirably adapted to produce a rich, heavy filler leaf. Unfortunately, the methods of curing and fermentation are not so controlled as to develop the best quality of the leaf, as is done in Cuba.

The tobacco soils of the Connecticut Valley, both in Massachusetts and in Connecticut, contain on the average considerably less than 5 per cent of clay. These soils are too light in texture for any of the staple farm crops. They are adapted to the quick-growing spring vegetables, but are not used to any great extent for these crops, except immediately around the cities and larger towns. The conditions seem to be peculiarly adapted to this particular grade of wrapper leaf tobacco.

It must not be forgotten, however, that fashion has much to do in the consumption of cigars. Just at present the demand is for light wrappers and mild-smoking cigars. A few years ago the demand was for heavier cigars, and these light soils of Connecticut had little or no value then for tobacco and were lying out as waste land. At that time the tobacco was grown mainly on the heavier soils and on the "meadow lands" of the Connecticut Valley. These meadow lands are very retentive of moisture and contain upward of 23 to 27 per cent of moisture, while the finest types of tobacco land in the Connecticut Valley contain only about 7 per cent. These meadow soils are therefore not used for tobacco at present, but if in the course of events the style should change and dark wrappers come into vogue, these lands will again be taken up and the present tobacco lands will have to be abandoned or used for other crops.

PENNSYLVANIA CIGAR TOBACCO LANDS.

The tobacco soils of Pennsylvania are confined mainly to a comparatively narrow belt bordering the Susquehanna River and to the broad expanse of limestone soils typically developed in York and Lancaster counties.

The better class of tobacco lands in Pennsylvania, and those which produce by far the finest wrapper leaf, are the light, alluvial soils along the river, similar in texture to the tobacco soils of the Connecticut Valley. The main crop, however, of the Pennsylvania tobacco has been grown on the limestone soils of York and Lancaster counties. These are a continuation of the great limestone valley extending down through Maryland and Virginia and to the great area of the Trenton limestone formation in Ohio and Kentucky, forming the great blue grass region of these States upon which the White Burley tobacco is at present grown.

This limestone soil, as it is exposed in the tobacco districts of Pennsylvania, is a strong clay soil, well adapted to grass, wheat, and corn. It forms one of the most productive areas in the State of Pennsylvania, and in this respect it is markedly different from the tobacco lands of the Connecticut Valley. There is considerable variety in the texture of the soils, as the limestone itself is not pure, but is mixed with shale. The amount of clay, therefore, in these Pennsylvania lands varies from about 13 per cent in the river soils and in the very shaly limestone soils to about 30 per cent on the average in the pure limestone soils. The former grade of soils is preferred just at present to the very heavy ones, as they produce a better grade of wrapper leaf. By proper cultivation, close planting, and especially by proper fermentation and grading of the leaf, the quality of the filler grown on the heavy limestone soils could unquestionably be greatly improved.

These soils maintain about 20 to 22 per cent of water.

OHIO CIGAR TOBACCO LANDS.

The cigar tobacco district of Ohio is situated in the southwestern part of the State and includes the country bordering the Miami River, Montgomery, Darke, and Preble counties forming the center of the district. The Miami Valley, in the tobacco area, is from 2 to 5 miles wide, level, and extremely fertile. Bordering the valley are upland rolling hills. Broad terraces extend back from the river in a number of places, giving second bottoms, beyond which come the great rolling red lands upon which tobacco is raised with great success. These soils are well drained, with numerous streams flowing out from between hills. Farther back on the level prairies the land is inclined to be wet and needs thorough underdraining to be profitably cropped. Throughout the whole tobacco area, underdrainage is practiced to a large extent.

The soil is derived from drift material which has been worked over and modified by subsequent action of water. The underlying rock is the Lower Silurian limestone shale, but it forms no feature of the surface, as it is covered by the drift material. There is quite a variety in the character of the soil, owing to the heterogenous nature of the material from which it has been derived. The bottom soils are, as a rule, much lighter in character than the upland soils. The second and third bottoms, in cases where they occur, are level terraces. The soils vary much, the black prairie soil and the red silty soil predominating. The soils of the rolling uplands are more uniform in character. The timber is mainly sugar tree, and on this sugar-tree land the finest grade of tobacco is produced. The sugar-tree soil is a thin, uniform, silty soil, with red clay or silty subsoil. The lower levels of this upland contain considerable areas of black land, which is considered the best land in the district for general agricultural purposes, but which produce too heavy a leaf and one of poor flavor, so that it is not desirable for tobacco culture. Wheat, corn, hay, and tobacco constitute the staple crops of the district, although on the sandy river lands truck and fruit growing are carried on to a large extent.

Three types of cigar leaf are raised in this district. The most popular at present is the Zimmer Spanish. This has small leaves about 12 inches long, of very fine texture and flavor. It produces about 1,000 pounds per acre. The old Ohio seed leaf is a very large, heavy leaf, 20 inches or more in length, and produces from 1,500 to 2,000 pounds per acre. This is little grown in the district at the present time. The Little Dutch has a thick, short, narrow leaf which produces about 1,200 pounds per acre and was at one time very extensively grown. These tobaccos are grown almost exclusively for filler purposes, and the soils have a large percentage of silt.

WISCONSIN TOBACCO SOILS.

The Wisconsin tobacco is used both as a wrapper and filler leaf to some extent, but the State is known in the markets as a binder State. The character of the leaf is midway between the Connecticut wrapper and the Pennsylvania filler.

The tobacco is grown in the southern part of the State on the prairies and oak openings. The prairies are a dark, rich loam, resting on a rather heavy silt or clay. The oak openings have a loam lighter in color but about the same in texture. Both are gently rolling and, as a rule, have good surface and under drainage. In texture the Wisconsin lands come between the Connecticut and the heavier limestone soils of Pennsylvania.

SOUTHERN CIGAR TOBACCO DISTRICTS.

Tobacco has been grown for many years in Florida, especially in the western part of the State. The tobacco grown there is mainly the Cuban type of cigar wrapper and filler, with some Sumatra lately introduced. The recent scarcity of Havana tobacco has given a great impetus to the cultivation of the crop in Florida, and very extensive arrangements have been made to introduce it to a large extent in the central part of the peninsula.

WESTERN FLORIDA.

The soils of the older Gadsden County district in the western part of the State are very different from any others which occur in Florida. They are the characteristic "red-land" soil of the Lafayette formation, similar to those found at Wedgefield and Aiken, S. C., which extend south through Georgia and form some of the western counties of Florida, with Quincy as a center. The soil is a light loam resting on a very strong red clay. The clay is exposed in all cuts and in the washings of the land, and is usually found from 8 to 18 inches below the surface. The country is quite rolling, well wooded with hard wood trees, and in the early spring it has the fresh green appearance of the country in the Valley of Virginia and in the tobacco area of Pennsylvania.

Both the Cuban and Sumatra types of tobacco are grown here, and both are used for wrappers as well as fillers. Unlike the imported Sumatra tobacco, the tobacco grown in Florida from Sumatra seed loses much of its bitter taste, while the sucker crop and inferior leaves are cured up with more body and are much better adapted to filler purposes.

The season is so long that two crops of tobacco can be produced in the same year, or two or three sucker crops can be grown after the main cutting has been taken. The sucker crop is stronger, heavier, and darker, and is used only as a filler.

The top soil is a light loam resting on a red-clay subsoil, and the character of the land as a tobacco soil depends largely upon the character of the red-clay subsoil and its depth below the surface. These lands maintain on an average only about 8 or 10 per cent of moisture, against 20 to 22 per cent maintained by the Pennsylvania and the Ohio lands.

THE FLORIDA PENINSULA.

Outside of this area in western Florida most important developments have recently been made around Ocala, Bartow, and Fort Meade. At Fort Meade, particularly, there is a well-organized company of Cubans with a large area in tobacco. The first crop was made in 1896. The tobacco was cured and fermented according to the Cuban processes, and without waiting to mellow with age, as is necessary to bring out the finest qualities of a tobacco, the crop was sold at Tampa for a very satisfactory price.

Tobacco growing on the peninsula is essentially a new industry, and comparatively little experience has been available except what has been collected during the season of 1897. The industry has been developed principally upon the post-oak lands around Ocala, and upon the hammock lands at Bartow and Fort Meade. There are large areas of these soils in the State which can be developed through the tobacco interest, and there is every reason to believe that the venture will be very successful. There is no reason to doubt that many of the pine lands are well suited to tobacco.

There is very little difference in the texture of the post-oak lands, the hammock lands at Fort Meade, and the pine lands. The difference in the soil which causes the distribution in the forest growth appears to be mainly due to the difference in the water content of the soils. The soils are all very light and sandy. They contain on an average less than 4 per cent of clay and less than 6 per cent of silt, fine silt, and clay. They contain over 50 per cent of "fine sand," so that they are relatively rather coarse and open. Notwithstanding this open texture the hammock soil at Fort Meade contains on an average about 8 per cent of water throughout the season, which is about as much as the tobacco lands of the Connecticut Valley contain. This water content, moreover, is for some reason more uniform, and the land can go for some time without rain with no serious injury to the crops. Nevertheless the planters have been greatly benefited by judicious systems of irrigation through overhead sprays. By thus keeping the plants continually and rapidly growing the crop will mature in forty-five days from the time the plants are set out. On account of the length of the season tobacco can be grown almost continually through the year, and crops can be set out almost every month in the year. Usually two or three crops are made and two or three sucker crops are produced. There is undoubtedly a vast area of land in Florida suited to tobacco, and the climate is unquestionably favorable for the production of a very fine quality of leaf. A very intelligent method of growing and fermenting is being practiced, and there is no reason why the industry should not be successful.

BRIGHT-TOBACCO LANDS.

The bright yellow tobacco used for cigarettes, plug wrappers, fillers, and cutting is grown mainly in Virginia, North Carolina, South Carolina, and East Tennessee. It is, however, produced in smaller quantities in several of the other Southern States. Wherever it is grown the industry is confined to a certain type of soil.

The typical bright-tobacco land consists of a loose, porous sand, containing not more than 8 or 10 per cent of clay. This sand must be at least 12 inches deep. Many areas are cultivated in which the sand extends to a depth of 5 or 10 feet or more, and a very fine quality of tobacco is produced. As a general rule the less clay the soil contains and the deeper the sand, the finer the quality of the tobacco, providing it keeps growing continuously. The trouble with such very light soils is that they produce but a small yield per acre and there is danger of drought, which would check the growth of the plant and cause the leaves to thicken. It is for this reason, therefore, that it is preferred to have the sand underlaid at a depth of 18 to 22 inches with a heavier clay, which tends to conserve the moisture supply of the soil and renders the plant less subject to the injurious effects of what would otherwise prove a severe drought.

The clay which underlies the bright tobacco lands of Virginia and North Carolina is the same as that upon which the heavy manufacturing and export tobacco is grown. Where this clay is exposed to the surface the heavy type of tobacco is produced; where it is covered from 12 to 20 inches with fine-grained sand the bright tobacco is produced the most profitably.

The country throughout these regions is generally quite rolling, with numerous "draws," or natural ditches, and streams, so that the land is well drained. The sandy covering is usually found on the ridges or slightly elevated plateaus, while the heavy clay may be exposed within a few feet, and the two types of tobacco successfully grown in the same field. For this reason it has never been easy to define the areas of the two types of tobacco; for both are grown in the same counties and frequently on the same farm.

The bright tobacco lands which have been examined contain, on the average, about 8 per cent of clay. This is quite uniform, the extreme range for profitable tobacco culture being probably between 6 and 12 per cent.

As the relation of the physical properties of the soil is not thoroughly understood or practically recognized by the growers, a large amount of land is now cultivated in bright tobacco which is not suited to this plant and which does not produce a good grade. On the other hand, there are large areas not at present under cultivation which could be developed into very fine tobacco lands. The typical bright tobacco soil is of little value for any of the staple farm crops, although, when suitably located near transportation lines, it is admirably adapted to the production of early vegetables, watermelons, and sweet potatoes.

MANUFACTURING-TOBACCO LANDS ON THE ATLANTIC.

Before the development of the White Burley industry the strong red-clay soils around Charlottesville, Lynchburg, and Danville, Va., and in Granville and neighboring counties of North Carolina, were extensively used for the production of the typical Virginia manufacturing and export tobacco. These areas are located mainly on the gabbro, gneiss, and Lafayette clays. The material is quite uniform, the red subsoils containing from 30 to 50 per cent of clay. The soils are very productive and are well suited to the staple farm crops, such as grass, wheat, and corn. Since the introduction of the White Burley tobacco, however, there has been a very noticeable decrease in the acreage in Virginia, especially of the soil adapted to the heavier types of tobacco, and the cultivation of tobacco on these lands has been almost abandoned. The industry is confined now principally to small areas along rivers, streams, or creeks, and upon recent deposits which can not well be referred to any of the older geological formations and which can not well be examined without a detailed examination of the larger part of the State.

The same remark holds true in regard to the tobacco industry in North Carolina. A great change has taken place very recently, and the acreage devoted to the heavier type of tobacco has been considerably reduced. These heavy clay lands are being used for other crops, and the tobacco is grown upon limited areas in certain districts where the quality of the tobacco produced is such as to make it reasonably profitable. Here, again, it is impossible to make any statement in regard to the tobacco district without making a detailed study of the soils of the State. There seems to be no general type of soil. The tobacco grown upon the soil which was formerly cultivated most extensively is no longer profitable.

WHITE BURLEY LANDS OF KENTUCKY AND OHIO.

The White Burley tobacco is confined to the well-marked type of soil of the Lower Silurian limestone in central and north central Kentucky and the adjacent counties of Ohio. This embraces the blue-grass region of Kentucky, and it is upon these fine, fertile, blue-grass soils that the White Burley is grown.

The country has the general appearance of an old limestone region, generally rolling and with frequent depressions, sinks, and caves. The hills, 400 to 500 feet high, bordering the Ohio River and extending from 6 to 10 miles back, are generally steep, and fields are often cultivated in tobacco with slopes as great as 45 degrees. The valleys are narrow, winding, and V-shaped, and no bottom lands are found excepting along the larger rivers and streams. The country back from the hills on the Ohio side is generally rolling. The drainage is excellent.

The tobacco lands on the Ohio side are all within the hills on the Ohio River and confined to two kinds of soil, popularly known as the "sugar-tree land" and "beech land." The beech lands lie low in the valley and are inclined to be wet, and do not produce the finest quality of leaf. The sugar-tree lands lie well up in the valleys and are considered the typical White Burley soil. Back from the hills in Ohio the soil becomes white, wet, and "crawfishy" and does not produce a fine quality of Burley. These flat lands are of drift origin, timbered with white oak, and usually need to be underdrained in order to produce well.

In Kentucky the tobacco area is confined to the Trenton and Hudson River limestones. Phosphatic limestone is frequently met with, while chert occurs only sparingly through the area.

The soils are all heavy clay of a uniform deep red color. The depth of the soil varies considerably, the rocks outcropping in many places, especially on the hillsides. Around Lexington the rock is on the average about 6 feet below the surface, while in the northern counties it is at a greater depth than this. The top soil is of light, loamy character, not inclined to form into clods when properly cultivated. The soil is adapted to grass, wheat, and corn, and has made famous, the world over, the blue-grass region of Kentucky. The subsoil contains on an average about 30 per cent of clay and maintains about 20 to 22 per cent of water.

EXPORT-TOBACCO LANDS OF KENTUCKY AND TENNESSEE.

The dark, heavy varieties of tobacco adapted to the export trade are extensively grown in western Kentucky and Tennessee on silty soils which are quite fertile in character. The whole area is divided into a number of districts, such as Clarksville, Hopkinsville, Jackson's Purchase, and the Green River district, but the character of the soil is quite uniform in all of these; the class of tobacco grown is generally the same. In each district the types of tobacco adapted to the foreign markets are grown, the types appearing to depend less upon the character of the soil than upon the character of the season, the cultivation, and curing of the crop.

The general character of the country is level or gently rolling, with broken and hilly country along the large water courses. Much of this land was formerly devoid of forest growth and called barrens. It was a prairie region, with trees only along the water courses, and prairie fires are supposed to have annually swept over the country. Since the country has become settled and the large fires prevented a luxuriant forest growth of hickory and oak has covered the land.

The counties of Kentucky bordering the Tennessee line are generally level, with occasional stretches of rugged country along the water courses, but with a soil of quite uniform texture. The southern boundary of the tobacco area is the Cumberland River, while the northern boundary is the Carboniferous hills of Kentucky. The tobacco district stretches around these hills, following the Subcarboniferous strata as far as the Ohio River on either side.

The soils are mainly derived from the St. Louis group of the Subcarboniferous, which are mainly limestone. The disintegrated material is so thick, that the rock is seldom exposed except where the material has been recently eroded. The drainage is excellent, and numerous sinks and caves are found through the country. The soil, whether upland or bottom, level or hilly, is usually of a decided silty character, closely approaching loess in texture. The subsoil has a typical bright red color, which extends to a considerable depth. Where this red color changes to a pale yellow or white the land becomes "crawfishy," and can be profitably cultivated only after under-drainage. The lack of color indicates a deficient drainage within recent times, and is due to the deoxidation of the iron compound in the decay of organic matters and the absence of sufficient oxygen from other sources to provide for the proper oxidation of the organic matter.

These soils contain on an average about 50 per cent of silt. The range is from about 40 to 60 per cent, some samples exceeding even this latter figure. With all such silty soils great care has to be taken in their cultivation. They are naturally quite fertile, but deteriorate very rapidly and excessively unless the fertility is maintained by judicious methods of cultivation and of cropping. Many of these tobacco soils have been run down with constant cropping in tobacco, but some of the worst cases have recently been brought up by rotation with wheat, corn, and clover, together with a judicious application of fertilizers, especially phosphatic manures. The value of careful tillage is becoming more apparent in the whole area, and it is generally recognized now that the quality of the tobacco and the price it brings on the market can be very materially influenced by the kind and condition of the cultivation.

The soils of the Lower Green River district lie within the Carboniferous strata along the Green River, and, although these are underlaid with sandstone, the soil proper presents the uniform silty character of the other export-tobacco districts.

The Jackson's Purchase region, lying between the Tennessee and Mississippi rivers, is made up mainly of loess and loam, and has the same silty character as the other districts and produces essentially the same type of tobacco.

The accompanying diagram illustrates graphically the relative proportion of the sand, silt, and clay in the soil adapted to different classes and types of tobacco, and shows, upon careful study, a marked relation between the texture of the soil and the grade of tobacco produced.

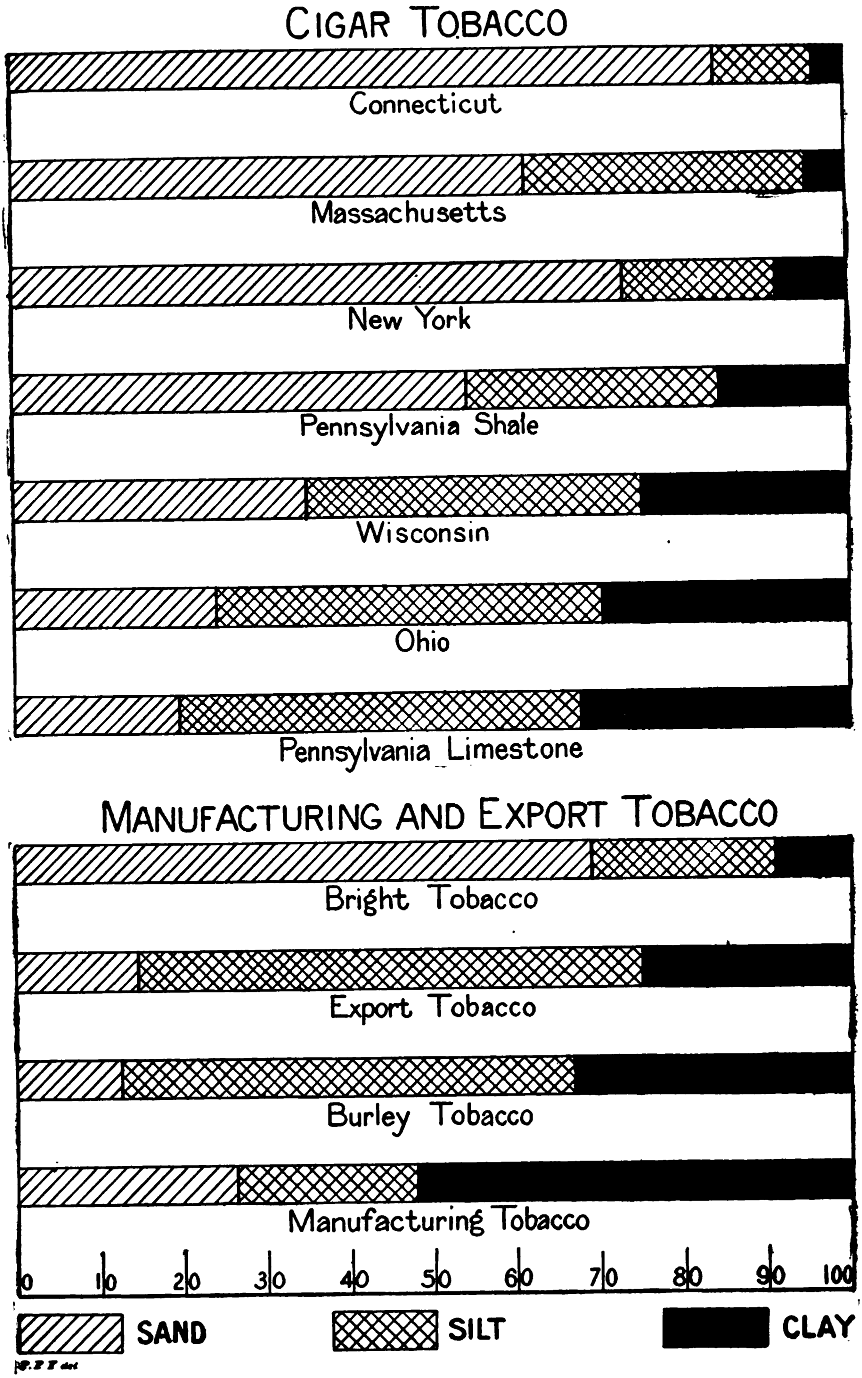

FIG. 1.—Relative proportions of principal constituents of tobacco soils.

THE WATER CONTENT OF TOBACCO SOILS.

The amount of water a soil contains depends largely upon the texture and structure, and is influenced, of course, by the character of the season. It varies from day to day, and these variations are exceedingly important in their effects upon the crop.

WATER IN THE NORTHERN CIGAR-TOBACCO SOILS.

Tobacco soils of the best grade in the Connecticut Valley maintain on an average about 7 per cent of water throughout the season. There are many soils cultivated in tobacco which average 10 or 12 per cent, but these do not produce a tobacco leaf of the finest texture and most desirable quality for the present market. On the other hand, there are soils cultivated in tobacco which maintain less water than this, and while in favorable seasons, when the tobacco is kept constantly growing, they produce a very fine and delicate leaf, it is not on the whole a safe or economical condition under which to grow the plant, on account of the small yield per acre and the injury liable to occur in dry seasons. The meadow lands of the Connecticut Valley, which were formerly cultivated in tobacco when a dark heavy leaf was in demand, contain on an average from 20 to 28 per cent of water. As already stated, these soils are entirely unfit for the production of the grade of tobacco necessary to meet the present market demands.

The tobacco soils of Pennsylvania, as already explained, are heavier than those of the Connecticut Valley and maintain on an average about 18 to 22 per cent of water.

Soils which produce the best wrapper leaf in Pennsylvania are those which have the lightest texture and contain the smallest water content, while the heaviest limestone soils maintain on an average 22 to 23 per cent of water and produce mainly a heavy strong filler leaf.

The soils of the tobacco district of Ohio are as heavy in texture as the limestone tobacco lands of Pennsylvania. They maintained on an average during the season of 1897 rather more than 27 per cent of water, but this was a wet season. It is probable that the mean water content of these soils in an average season would amount to about 23 to 24 per cent of water. The tobacco grown under these conditions is used almost exclusively as a filler leaf.

It is unquestionably true that the texture of the soil and the meteorological conditions, with the resultant water content, determine to a marked extent the character and grade of leaf which can be produced. In this, as in all other agricultural lines, the aim should be to recognize the conditions and adopt the crop, the method of cultivation or fermentation, and the grade of leaf which those conditions are best adapted to produce. If the general character of the soil in a locality is adapted to the wrapper leaf, use only such soils as may be reasonably expected to give the best wrapper leaf. If, on the contrary, the soils of the district are adapted only to filler leaf, use only such of the soils as are best adapted to this grade, and plant, cultivate, manure, and ferment the crop for the specific purpose of producing a filler leaf of superior quality. Most of the tobacco soils of the Northern States will not produce equally good fillers and wrappers.

WATER IN THE FLORIDA TOBACCO SOILS.

Records have been kept during several seasons of the moisture conditions in the soils of the Gadsden County district of west Florida and of the newer tobacco district of Fort Meade, in the peninsula. The mechanical analyses showed that the tobacco land in western Florida consisted of a light loam, about 12 inches deep, resting on a heavy red clay, which is naturally well drained. The hammock soil of Fort Meade is, on the other hand, a very light sandy soil, extending down to a very considerable depth. Both soils produce a hard wood growth. Strange to say, in spite of the great difference in the texture of the subsoil, the soils of these two localities maintain about the same amount of moisture. The average water content of the soil at Fort Meade, for a period of four months, in 1897, was 8.6 per cent, while the mean water content of the soil at Quincy for the same time was 8.26 per cent. It is a surprising thing to find that these soils maintain about the same amount of water, but this is in line with the general facts that the hammock soils of Florida maintain very much more water than would be expected from their texture, or than is maintained by soils of similar texture farther north along the Atlantic coast.

No records have been kept of the moisture conditions in the tobacco soils of Texas or of California, and unfortunately none have been kept in the tobacco soils of Sumatra and Cuba.

WATER IN THE SOILS OF THE MANUFACTURING AND EXPORT TOBACCO DISTRICTS.

As in the northern cigar-tobacco district, it will be seen that the texture of the soil and the water content appear to determine the type of tobacco produced. The typical soils for the bright yellow tobacco of Virginia, North Carolina, and East Tennessee maintain on an average about 7 per cent of water. Where the soils contain less than this the leaf is inclined to be thinner in texture and to have a better color, but the yield per acre is small, and the most economical conditions on the whole are maintained by these soils having from 7 to 8 per cent of clay and maintaining on an average about 7 or 8 per cent of water. As the soil becomes heavier in texture and the amount of water increases, other grades and types of tobacco are produced.

The export tobacco lands of Kentucky and Tennessee contain about 22 or 23 per cent of clay and from 40 to 60 per cent of silt. These soils contain on an average about 15 per cent of water.

The characteristic soil of the limestone area of Kentucky, adapted to the White Burley tobacco, as the result of several years' investigation, may be said to maintain on an average about 20 per cent of water.

Records have not been kept of the water content of the manufacturing tobacco soils of Virginia, but from investigations which have been made on adjacent lands it is probable that the mean water content of these soils, having as much as 40 per cent of clay, will not be far from 20 or 22 per cent of moisture.

CONTROL OF THE WATER SUPPLY OF THE SOIL.

It is evident from the work that has been done in the Division of Soils that the peculiar adaptation of certain soils to certain types of tobacco is largely dependent upon the relation of the soils to water and the amount of water they maintain. The great difference in the water content of soils adapted to the different types of tobacco has been pointed out. Tobacco of a given quality can only be grown economically where the conditions are adapted to it, but these conditions are liable to vary in any soil throughout the season. It therefore becomes necessary in order to secure the best results to maintain some control over the water supply of the soil, in order to keep the conditions as nearly perfect as possible throughout the season. Much can be done to control the water supply through methods of preparing the land and of cultivating the crop, as has been pointed out in several bulletins of the Division of Soils and in numerous publications from other sources.

The farmer should select the type of tobacco best suited to his locality and to the peculiar soil conditions with which he has to work, and should adopt such methods of cultivation as will maintain as nearly as possible the best conditions for the quality of leaf it is proposed to raise.

FARMERS' BULLETINS.

These bulletins are sent free of charge to any address upon application to the Secretary of Agriculture, Washington, D. C. Only the following are available for distribution:

No. 16. Leguminous Plants for Green Manuring and for Feeding. Pp. 24. No. 19. Important Insecticides: Directions for Their Preparation and Use. Pp. 20. No. 21. Barnyard Manure. Pp. 32, figs. 7. No. 22. The Feeding of Farm Animals. Pp. 32. No. 23. Foods: Nutritive Value and Cost. Pp. 32, charts 2. No. 24. Hog Cholera and Swine Plague. Pp. 16. No. 25. Peanuts: Culture and Uses. Pp. 24, fig. 1. No. 26. Sweet Potatoes: Culture and Uses. Pp. 30, figs. 4. No. 27. Flax for Seed and Fiber. Pp. 16. No. 28. Weeds: and How to Kill Them. Pp. 32, figs. 11. No. 29. Souring of Milk, and Other Changes in Milk Products. Pp. 23. No. 30. Grape Diseases on the Pacific Coast. Pp. 15, figs. 3. No. 31. Alfalfa, or Lucern. Pp. 24, figs. 3. No. 32. Silos and Silage. Pp. 32, figs. 10. No. 33. Peach Growing for Market. Pp. 24, figs. 21. No. 34. Meats: Composition and Cooking. Pp. 29, figs. 4. No. 35. Potato Culture. Pp. 23, figs. 3. No. 36. Cotton Seed and Its Products. Pp. 16. No. 37. Kafir Corn: Characteristics, Culture, and Uses. Pp. 12, fig. 1. No. 38. Spraying for Fruit Diseases. Pp. 12, figs. 6. No. 39. Onion Culture. Pp. 31, figs. 3. No. 40. Farm Drainage. Pp. 24, figs. 6 No. 41. Fowls: Care and Feeding. Pp. 24, figs. 4. No. 42. Facts About Milk. Pp. 29, figs. 8. No. 43. Sewage Disposal on the Farm, and Protection for Drinking Water. Pp. 20, figs. 8. No. 44. Commercial Fertilizers: Composition and Use. Pp. 24. No. 45. Some Insects Injurious to Stored Grain. Pp. 24, figs. 17. No. 46. Irrigation in Humid Climates. Pp. 27, figs. 4. No. 47. Insects Affecting the Cotton Plant. Pp. 32, figs. 18. No. 48. The Manuring of Cotton. Pp. 16. No. 49. Sheep Feeding. Pp. 24. No. 50. Sorghum as a Forage Crop. Pp. 20, fig. 1. No. 51. Standard Varieties of Chickens. Pp. 48, figs. 44. No. 52. The Sugar Beet. Pp. 48, figs. 24. No. 53. How to Grow Mushrooms. Pp. 20, figs. 14. No. 54. Some Common Birds in Their Relation to Agriculture. Pp. 40, figs. 22. No. 55. The Dairy Herd: Its Formation and Management. Pp. 24. No. 56. Experiment Station Work—I. Pp. 31, figs. 10. No. 57. Butter Making on the Farm. Pp. 15. No. 58. The Soy Bean as a Forage Crop. Pp. 24, figs. 5. No. 59. Bee Keeping. Pp. 32, figs. 19. No. 60. Methods of Curing Tobacco. Pp. 16. No. 61. Asparagus Culture. Pp. 40, figs. 17. No. 62. Marketing Farm Produce. Pp. 28, figs. 7. No. 63. Care of Milk on the Farm. Pp. 40, figs. 9. No. 64. Ducks and Geese: Standard Breeds and Management. Pp. 48, figs. 37. No. 65. Experiment Station Work—II. Pp. 32, figs. 7. No. 66. Meadows and Pastures in the Middle Eastern States. Pp. 28, figs. 9. No. 67. Forestry for Farmers. Pp. 48, figs. 15. No. 68. The Black Rot of the Cabbage. Pp. 22, fig. 1. No. 69. Experiment Station Work—III. Pp. 32, figs. 2. No. 70. The Principal Insect Enemies of the Grape. Pp. 23, figs. 12. No. 71. Some Essentials in Beef Production. Pp. 24, figs. 17. No. 72. Cattle Ranges of the Southwest. Pp. 32, figs. 9. No. 73. Experiment Station Work—IV. Pp. 32, figs. 3. No. 74. Milk as Food. Pp. 39, charts 2. No. 75. The Grain Smuts: How They are Caused and How to Prevent Them. Pp. 20, figs. 8. No. 76. Tomato Growing. Pp. 30. No. 77. The Liming of Soils. Pp. 19. No. 78. Experiment Station Work—V. Pp. 32, figs. 2. No. 79. Experiment Station Work—VI. Pp. 28, figs. 2. No. 80. The Peach Twig-borer: An Important Enemy of Stone Fruits. Pp. 16, figs. 5. No. 81. Corn Culture in the South. Pp. 24. No. 82. The Culture of Tobacco. Pp. 24. No. 83. Tobacco Soils. Pp. 23, fig. 1. No. 84. Experiment Station Work—VII. Pp. 32, figs. 8. No. 85. Fish as Food. Pp. 30. No. 86. Thirty Poisonous Plants. Pp. 32, figs. 24. No. 87. Experiment Station Work—VIII. Pp. 32, figs. 6. No. 88. Alkali Lands. Pp. 23, fig. 1. No. 89. Cowpeas. Pp. 16, fig. 1. No. 90. The Manufacture of Sorghum Sirup. Pp. 32, figs. 9. No. 91. Potato Diseases and Their Treatment. Pp. 12, figs. 4. No. 92. Experiment Station Work—IX. Pp. 30. No. 93. Sugar as Food. Pp. 27. No. 94. The Vegetable Garden. Pp. 24, figs. 8. No. 95. Good Roads for Farmers. Pp. 47, figs. 49. No. 96. Raising Sheep for Mutton. Pp. 48, figs. 18. No. 97. Experiment Station Work—X. Pp. 32, figs. 5. No. 98. Suggestions to Southern Farmers. Pp. 48. No. 99. Three Insect Enemies of Shade Trees. Pp. 30, figs. 11. No. 100. Hog Raising in the South. Pp. 40. No. 101. Millets. Pp. 28, figs. 6. No. 102. Southern Forage Plants. Pp. 48, figs. 14. No. 103. Experiment Station Work—XI. Pp. 32, figs. 5. No. 104. Notes on Frost. Pp. 24. No. 105. Experiment Station Work—XII. Pp. 32, figs. 4. No. 106. Breeds of Dairy Cattle. Pp. 48, figs. 21. No. 107. Experiment Station Work—XIII. Pp. 32, figs. 3. No. 108. Saltbushes. Pp. 20, figs. 9. No. 109. Farmers' Reading Courses. Pp. 20. No. 110. Rice Culture in the United States. (In press.)

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264

U. S. DEPARTMENT OF AGRICULTURE.

FARMERS' BULLETIN No. 84.

Experiment Station Work,

VII.

HOME-MIXED FERTILIZERS.
FORCING ASPARAGUS IN THE FIELD.
FIELD SELECTION OF SEED.
POTATOES AS FOOD FOR MAN.
CORN STOVER AS A FEEDING STUFF.
FEEDING VALUE OF SUGAR BEETS.
SALT-MARSH HAY.
FORAGE CROPS FOR PIGS.
GROUND GRAIN FOR CHICKS.
SKIM MILK FOR YOUNG CHICKENS.
BY-PRODUCTS OF THE DAIRY.
STRIPPER BUTTER.
CURD TEST IN CHEESE MAKING.
GAPE DISEASE OF CHICKENS.

PREPARED IN THE OFFICE OF EXPERIMENT STATIONS.

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1898.

CONTENTS OF THE SERIES OF FARMERS' BULLETINS ON EXPERIMENT STATION WORK.

I. (Farmers' Bul. 56).—Good v. Poor Cows; Corn v. Wheat; Much v. Little Protein; Forage Crops for Pigs; Robertson Silage Mixture; Alfalfa; Proportion of Grain to Straw; Phosphates as Fertilizers; Harmful Effects of Muriate of Potash; Studies in Irrigation; Potato Scab; Barnyard Manure.

II. (Farmers' Bul. 65).—Common Crops for Forage; Stock Melons; Starch in Potatoes; Crimson Clover; Geese for Profit; Cross Pollination; A Germ Fertilizer; Lime as a Fertilizer; Are Ashes Economical? Mixing Fertilizers.

III. (Farmers' Bul. 69).—Flax Culture; Crimson Clover; Forcing Lettuce; Heating Greenhouses; Corn Smut; Millet Disease of Horses; Tuberculosis; Pasteurized Cream; Kitchen and Table Wastes; Use of Fertilizers.

IV. (Farmers' Bul. 73).—Pure Water; Loss of Soil Fertility; Availability of Fertilizers; Seed Selection; Jerusalem Artichokes; Kafir Corn; Thinning Fruit; Use of Low-grade Apples; Cooking Vegetables; Condimental Feeding Stuffs; Steer and Heifer Beef; Swells in Canned Vegetables.

V. (Farmers' Bul. 78).—Humus in Soils; Swamp, Marsh, or Muck Soils; Rape; Velvet Bean; Sunflowers; Winter Protection of Peach Trees; Subwatering in Greenhouses; Bacterial Diseases of Plants; Grape Juice and Sweet Cider.

VI. (Farmers' Bul. 79).—Fraud in Fertilizers; Sugar-beet Industry; Seeding Grass Land; Grafting Apple Trees; Forest Fires; American Clover Seed; Mushrooms as Food; Pigs in Stubble Fields; Ensiling Potatoes; Anthrax.

LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
OFFICE OF EXPERIMENT STATIONS,
Washington, D. C., September 30, 1898.

SIR: The seventh number of Experiment Station Work, prepared under my direction, is transmitted herewith with the recommendation that it be published as a Farmers' Bulletin.

Respectfully,

A. C. TRUE,
Director.

Hon. JAMES WILSON,
Secretary of Agriculture.

CONTENTS.

Page.
Home-mixed *v.* factory-mixed fertilizers 5
Forcing asparagus in the field 6
Field selection of seed 8
Potatoes as food for man 11
Corn stover as a feeding stuff 12
The feeding value of sugar beets 15
Salt-marsh hay 16
Forage crops for pigs 18
Ground grain *v.* whole grain for chicks 19
Skim milk for young chickens 20
By-products of the dairy 20
Stripper butter 24
Curd test in cheese making 24
    Home-made test 25
    Improved curd test 26
    Interpretation of results 27
Gape disease of chickens 28
Explanation of terms 30
    Terms used in discussing fertilizers 30
    Terms used in discussing foods and feeding stuffs 30
    Miscellaneous terms 31

ILLUSTRATIONS.

Page.
FIG. 1. The home-made curd test 25
2. Different stages of home-made test 25
3. Section of improved curd test 26
4. Improved test bottle 26
5. Curd from good milk 27
6. Curd from bad milk 27
7. Floating curd from very bad milk 27
8. Dissection of a chick affected with gapes, the trachea pinned open ... 28

EXPERIMENT STATION WORK—VII.[1]

HOME-MIXED V. FACTORY-MIXED FERTILIZERS.

It has been shown in a previous bulletin of this series (Farmers' Bul. 65) from the work of various experiment stations that it is perfectly practicable for farmers to buy unmixed fertilizing materials and prepare their own fertilizer mixtures, and that by so doing they may materially reduce the cost of their fertilizers.

Various objections have been raised to the practice of home-mixing.

Farmers are persuaded that the compounding of fertilizers is an intricate and difficult operation, requiring extensive acquaintance with chemistry, costly machinery, and great technical skill..

The case well illustrates the old adage, that a half truth is a whole falsehood. The production and manufacture of fertilizing materials—that is, the selection, quarrying, grinding, and acidulation of phosphatic rock; the drying and grinding of slaughterhouse refuse, the production and refining of such materials as nitrate of soda, sulphate of ammonia, and muriate of potash—all these are distinctly manufacturing processes which require chemical or technical knowledge, skill in manipulation, and expensive machinery. But these operations are entirely separate and distinct from the compounding of mixed fertilizers. Each of the materials named comes from the manufacturer in condition to be used by itself as a fertilizer and each one is so used for special purposes. The compounding of these materials under a proprietary brand into a mixed fertilizer is no more a manufacture than is the mixing of a ration of corn meal and bran to be fed to a cow. The only difference is that the ration which is designed to be distributed uniformly to thousands or millions of plants requires to be more carefully mixed than that fed to a single cow. If we were feeding each plant by itself no mixing would be necessary, or if we were giving the different elements of a ration at different times; as for instance, when we apply superphosphate and muriate of potash to wheat in the fall and follow with nitrate of soda in the spring.

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[1] This is the seventh number of a subseries of brief popular bulletins compiled from the published reports of the agricultural experiment stations and kindred institutions in this and other countries. The chief object of these publications is to disseminate throughout the country information regarding experiments at the different experiment stations, and thus to acquaint our farmers in a general way with the progress of agricultural investigation on its practical side. The results herein reported should for the most part be regarded as tentative and suggestive rather than conclusive. Further experiments may modify them, and experience alone can show how far they will be useful in actual practice. The work of the stations must not be depended upon to produce "rules for farming." How to apply the results of experiments to his own conditions will ever remain the problem of the individual farmer.—A. C. TRUE, Director, Office of Experiment Stations.

This point, of the essential difference between those operations which are legitimately called manufacturing and those which are simply mixing, should be clearly understood.

When the farmer learns that he can mix his own fertilizers and thereby materially reduce their cost the use of fertilizing materials will be largely increased, and the final outcome will be a benefit and not an injury to the legitimate trade in fertilizers.[1]

In order to determine whether fertilizers so mixed are any less effective than factory-mixed goods, the Ohio Station began in 1897 an experiment in which a few standard brands of factory-mixed fertilizers are being compared with home mixtures of tankage, acid phosphate, and muriate of potash, containing as nearly as possible the same amounts of potash, phosphoric acid, and nitrogen claimed for the factory-mixed goods. The experiments were located on heavy white-clay soil, and a rotation has been planned to include the three crops, corn, wheat, and clover, to follow each other in a three-year course, the fertilizers being applied to the corn and wheat. Up to the present, only the results with corn have been reported. These show that the home-mixed fertilizers gave yields fully equal to those produced by the factory-mixed goods. Basing the cost of the factory-mixed fertilizers upon what the station paid for them in small lots (200-pound sacks) at the factory and the cost of the home mixtures at the regular retail market price of the materials in single-sack lots, with freight to the station added, the saving on the home-mixed fertilizers was from $6 to $12 per ton.

Acting under the advice of the station a company of farmers bought several carloads of fertilizing materials and mixed for themselves last fall. These farmers first obtained propositions to furnish the desired materials from a considerable number of manufacturers and dealers. Selecting those which offered the best terms they concluded their purchase, the materials being guaranteed to carry a definite percentage of the required fertilizing elements. The materials, when received, were mixed according to formulæ furnished by the station, and the result of their use, as shown in the fall growth of the wheat to which they were applied, a few samples of factory-mixed fertilizers of similar composition being used alongside has been such as to lead to much larger purchases for this season's operations. The final cost of their lot of fertilizer, including cost of materials, freight, and mixing, was less by more than $500 than the lowest price at which the company was offered an equal quantity of factory-mixed fertilizers of equivalent composition and on the same terms of payment.

FORCING ASPARAGUS IN THE FIELD.

Asparagus is commonly forced by transplanting mature roots to some warm place, as in hotbeds or under greenhouse benches. Strong plants four or five years old are removed from the field late in the fall with as little damage to them as possible and stored in a cold place until wanted for forcing, when they are set close together in the beds prepared for them and covered with several inches of soil. In about two weeks cuttings can be made, and the plants will continue to yield for about six weeks. Since forced plants do not grow by becoming rooted in the soil, but are produced from material stored up in the roots the previous summer, when this reserve material is exhausted the roots must be thrown away and replaced by others. It will, therefore, be seen that this is rather a wasteful and expensive method of forcing asparagus.

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[1] Ohio Sta. Bul. 93.

To overcome this difficulty various means have been devised to force asparagus in the field, where it is so well established that it continues growth in the summer as though it had not been forced the previous winter. A simple and rather common method of accomplishing this is to place barrels or half barrels over clumps of asparagus very early in the spring and pile fermenting manure about them, the warmth from the manure forcing the shoots into rapid growth. When the forcing season is over and danger from frosts is past, the barrels are removed and the plants continue growth in the open air. Sometimes asparagus is forced by placing frames covered with sash over the plants in the field, the rows of asparagus being set rather close together. This is considered a very profitable method by many market gardeners. Another method of forcing asparagus in the field is to dig ditches between the rows and fill them with fermenting manure. The surface of the bed may also be mulched with manure. Sometimes brick tunnels are laid between the rows and hot-water pipes placed inside them to furnish the heat.

A method has been devised and used at Cornell University by which asparagus is grown in a house, the roof of which is removed in summer. The frame for a house 20 by 50 feet consists of a ridge and three pairs of rafters of gas pipe, over which canvas or muslin is stretched to form a roof. The walls are but 18 inches high. The heat is furnished by steam carried in one supply pipe near the ridge and two return pipes on either side of the house. By this method plants are easily forced into growth in January or February.

Another method of forcing asparagus in the field has recently been reported by the Missouri Station. The method is as follows: Trenches are made by running a plow twice in a place between the rows so as to throw the soil onto them. The trenches are then made uniform by means of a spade. When finished they are 3 or 4 inches lower than the crown of the plants. They are covered with 12-inch boards resting on 4-inch blocks on either side of the trenches, thus forming tunnels between the rows. The boards are covered with 2 or 3 inches of soil and over the whole bed 5 or 6 inches of horse manure is placed. Steam from the boiler is carried to the end of the central tunnel by a steam pipe and from there forced into the various tunnels through a steam hose. The steam comes into direct contact with the soil, penetrates it readily, and thereby warms the whole bed uniformly to the desired temperature, keeps the soil moist, and maintains a continuous fermentation of the manure mulch. About five minutes at a time was as long as steam could be forced into the tunnels without danger of injuring the plants.

This method was first tested at the station in the winter of 1896.

The field used had been planted to asparagus some ten years previous to the experiment. Six rows, 4 feet apart and 50 feet long, were prepared for forcing. Steam was first applied November 14. It was discharged in each tunnel not over five minutes at a time, about an hour being required to heat the bed to a temperatue of 60° F. After the first day the bed was steamed on an average of twice in three days and only for five minutes for each tunnel. The first asparagus was cut ten days after steaming was begun. It was as large as that ordinarily produced in spring and much more crisp. Cuttings were made almost daily for a month, when the growth became weak. The second test was begun December 16 and carried out as in the first test. The bed prepared for forcing was 25 by 75 feet. The first cutting was made two weeks after the first steaming. The time of cutting was more irregular than in the first test and was prolonged about two months. The weather being colder, somewhat more steam was required than in the first test. The plants forced were allowed to grow without cutting during the summer of 1897, and the spring growth of 1898 showed that one season's growth after forcing was sufficient for the plants to regain their normal vigor. In the winter of 1897–98 a test was made with a bed 25 feet square to determine the amount of coal necessary to force a given area of asparagus and the value of the product. The steam was first used December 29, the first asparagus was cut January 12, and cutting was continued until February 25. Steam was forced into the tunnels a total of 60¼ hours; 2,308 pounds of coal, valued at $1.82, was used in heating the bed. The yield was 162 bunches (80 pounds), valued at from 10 to 20 cents per bunch.

FIELD SELECTION OF SEED.

The improvement of cultivated plants is an all-important question in agriculture the world over and one which will disappear only with the vocation itself. Nearly two thousand years ago the Roman writers on agriculture recommended the careful selection of seed wheat, and it is not improbable that selection has been practiced from the remotest antiquity from which the cultivation of wheat dates. The wheats of ancient Egypt even were of excellent quality, and the limit of that degree of general development which can be attained by selection has, perhaps, been reached not only in wheat but in other ordinary farm crops. The principles of selection, however, must not be abandoned, but rather applied with precision to prevent degeneration and to preserve the high degree of development which has been reached through years of labor and care. The present condition of our grains does not preclude the possibility of establishing new varieties. Variations occur constantly in all crops, and the farmer, by heeding these hints of nature, may give permanence to a desirable quality which has shown itself in a single plant. The improvement of some plants, as the sugar beet, for instance, is mainly the work of specialists, but the improvement of our common crops may receive the attention of the farmer and result in profitable reimbursement for the time and labor expended. It is also probable that the question of varieties is worthy of a greater consideration than it ordinarily receives. In a variety test with wheat recently conducted at the Pennsylvania Station, the best yielding variety produced 13.44 bushels per acre more than the variety giving the smallest yield, the one producing a little over 45 per cent more than the other.

The variations in plants are not always desirable, for the degeneration or "running out" of a variety is a form of variation which must be guarded against at all times. The qualities usually sought after are increased size of the grain or kernel and the yield in general, and a preferable change in the color of the grain and the time of ripening. The hardiness of a variety also is of great importance and is a factor which should be carefully considered, especially in connection with the improvement of our winter wheats. We have a good example of this in the Dawson Golden Chaff Wheat, which is of rather recent origin and which has given some very gratifying results. A bulletin of the Michigan Station describes it as follows:

> This variety originated in 1885, one stool containing five stalks being found at harvest time in that year on a bare exposed hill in a field of White Clauson where the surrounding wheat had been winterkilled. The farm on which it originated is located about 2 miles west of Galt, Ontario, and was owned at the time by Robert Dawson, who discovered, propagated, and introduced this variety. * * * For two years it * * * stood at the head of the varieties tested in the cooperative experiments conducted by the Ontario Agricultural College * * * and for three years it * * * stood first among the fifty-three varieties of wheat grown for trial on the experimental grounds connected with that college. Over a large part of Ontario it had become the leading market variety, being in especial demand to mix in grinding with spring wheat from the Northwest, and sometimes bringing an advance over the market price for that purpose. * * * The special merits of this variety, aside from the color and quality of the grain, are its hardiness and stiffness of straw, adapting it to cultivation on low, black land where many varieties winterkill and where the White Clauson is inclined to lodge and fail to properly fill.

This promising variety was obtained by selection in the field. Ordinarily the farmer makes his selection of seeds of wheat, oats, barley, etc., by means of the fanning mill, and his seed corn is selected from the crib or at husking time. These methods are a step in the right direction, and undoubtedly much good has come from them, but they are at best incomplete. This selection disregards everything except the condition of the grain. In selecting seeds the individual plants which produce them should be taken into consideration as well as the quality of the seed itself. Even weak and poorly developed plants are able to produce some well-developed seeds. A small stalk of corn may produce a large ear, and a poor wheat plant may produce some large grains in a head incompletely filled. These facts present a strong argument in favor of field selection as the most logical method of selecting the seeds. The selection of seeds of wheat, oats, barley, rye, etc., from the growing crops presents greater difficulties than the field selection of seed corn; still it is not beyond accomplishment. For the selection of seeds of small grain, Beseler, a German writer, recommends the gathering of the best-developed heads from plants typical of the variety. The heads are thrashed and the heaviest grain retained for seed. He advises to sow this selected seed on a special plat, in drills far enough apart to admit of cultivation, placing a few grains at intervals of 6 inches in the drill. When ripe the grain should be carefully thrashed, and again the best and heaviest grains selected for seed. In this way, it is believed, a variety may readily be improved and kept up to its standard of excellence. The New Mexico Station, in a bulletin on this subject, gives practically the same advice.

> The most logical way of selecting seeds of wheat, oats, rye, and barley would be at time of ripening in the field, selecting the longest and best filled heads, containing the largest, plumpest, and heaviest grains which grow in short thick stalks. * * * Enough heads can be gathered in this way in a few hours to furnish seed to produce the following year sufficient seed to supply the wants of the average farmer. * * * The practice of selecting Indian corn from seed from the crib or at husking time * * * is not altogether to be commended. * * * The best method is to select the ears before the stalks are cut, choosing those with not less than two well-formed ears on a stalk, which should be of low growth and well furnished with leaves, and ears set low to the ground. The plants should be vigorous and healthy. The ears selected should combine early maturity and uniformity of ripening.

In connection with this the results of experiments with wheat to determine the influence of the selection of seed made at Göttingen, Germany, will be of interest. The results in this experiment indicate that seed from large heads selected for a number of years produced a greater total yield than seed selected from small heads. The thickness, length of the straw, and the length of the upper internode were found to be greater in the plants grown from seed taken from large heads, and the number of internodes was also somewhat greater. Seed taken from heavy-culmed plants produced a heavier, stronger, and somewhat longer straw than seed taken from thin-culmed plants; the number of internodes was also found to be hereditary. The progeny of five-noded plants produced a larger total crop, stronger and longer culms, and longer heads than the progeny of four-noded ones. The plants were grown in pots, and it was observed that where one plant was grown in a pot the plant had a smaller number of internodes than where eight plants were grown in a pot. It is concluded from this that growth in a well-lighted position favors the strengthening of the culm and reduces the number of internodes. The results of an experiment with rye carried out in Germany by Westermeier show that the color of the seed grain is a factor of considerable importance in determining the character of the product.

These and other experiments of similar nature all go to show that not only the size and character of the grain but the development and characteristics of the entire plant—leaf, stem, nodes, etc.—must be taken into account in the effort to improve varieties.

The experiments of Girard in France and of several of the experiment stations in this country have justified the usual practice of successful growers in carefully selecting seed potatoes. By selecting for several generations average-sized tubers from the best hills Girard effected a considerable improvement in productiveness. To ascertain the best hills by digging each is exceedingly laborious, but Girard found that the best hills in an evenly manured field containing only one variety were those in which the vines were most vigorous. Selection was thus rendered easy by means of stakes placed beside the luxuriant plants.

The North Dakota Station sums up three years' experiments along this line with potatoes as follows:

"Selection of large-size tubers from the general crop as stored in the bin will not, with any desired certainty, make the crop a better one; for some hills which naturally yield many tubers of off-form and small size may furnish a large number of the tubers for the next crop. * * * Selection should be done in the field at digging time, and should be made from those hills which produce potatoes of the form and character desired," taking into consideration not only the yield and character of the tubers but also the growth and vigor of the vines; i. e., "the entire aspect of the plant rather than the single feature desired."

POTATOES AS FOOD FOR MAN.

The potato is a staple article of diet in almost every household. The universality and extent of its consumption would seem sufficient to prove it to be a wholesome and nutritious food. The statement, however, is frequently met with in popular articles that potatoes are not a wholesome food. So far as can be learned this is a purely gratuitous assumption. While it is possible that there are persons with whom potatoes do not agree, or who for some reason are compelled to forego starchy foods, there is no reason to suppose that potatoes are not as a rule a useful and wholesome article of diet.

The most important groups of constituents in foods are protein (nitrogenous matter), fats, and carbohydrates (starches, sugars, etc.). The potato is essentially a starchy food, and eaten alone it would furnish a very one-sided, badly balanced diet, which would probably prove unwholesome to most people. When eaten with meat, eggs, fish, etc., which are essentially nitrogenous foods, an evenly balanced diet, which is most conducive to health and vigor, is secured. The table (p. 12) affords a means of comparing the composition of the edible portion of foods rich in carbohydrates, like potatoes, flour, and bread, with those rich in protein—beefsteak, codfish, etc.

Composition of potatoes compared with that of other common food products.

	Water.	Protein.	Carbohydrates.	Fat.	Ash.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Potatoes	78.9	2.1	18.0	0.1	0.9
Flour	12.5	11.3	74.6	1.1	.5
Bread, white	35.4	9.5	52.8	1.2	1.1
Turnips	88.9	1.4	8.7	.2	.8
Cabbage	90.3	2.1	5.8	.4	1.4
Beefsteak, round	68.5	20.4	0.0	10.0	1.1
Fresh codfish	82.6	15.8	0.0	.4	1.2

As the table shows, the potato contains a high percentage of water, although not as much as turnips, cabbage, and similar foods. The greater part of the dry matter of potatoes is carbohydrates (principally starch).

Chemical analysis thus shows that the practice, which has become so general, of serving potatoes with meat and similar foods is based upon scientific principles, one food supplying the deficiencies of the other.

In experiments on the digestibility of potatoes by man, recently made at the Minnesota Experiment Station, it was found that 71.9 per cent of the protein and 93 per cent of the carbohydrates were digested or assimilated. In these experiments the potatoes were eaten with some eggs, milk, and cream, so that the conditions may be assumed to be about normal.

As was stated above, carbohydrates are an essential of a well regulated diet. The experiments just referred to show that potatoes properly cooked furnish such material in a digestible form. They have been a staple article of diet for many years without harmful results, and therefore the conclusion that under ordinary circumstances they are other than a useful and wholesome food seems unwarranted.

CORN STOVER AS A FEEDING STUFF.

The Maryland Experiment Station has published the results of some investigations which show anew the value of corn stover as a feeding stuff, provided it is prepared so it can be eaten by stock without waste or danger to health. This work takes up the matter from a new standpoint—that of feeding the stover cleaned of the pith. A large part of the bulk of cornstalks and about one-fifth of their weight is composed of pith. This is generally considered to be composed very largely of cellulose and to be of very little value for feeding. Recently a number of uses have been found for the pith in the arts, and a process has been patented and factories erected for the separation of the pith on a commercial scale. In this process the stover is dried, the blades and husks are removed, and the stalks are ground. The pith, being lighter than the rest of the cornstalk, is separated from it by winnowing. The remainder is used for feeding, and has been designated the "new corn product." It was this material which served for the investigation at the Maryland Station.

The composition of this material, as compared with that of corn fodder from which it was made, and of shredded corn is shown below:

Composition of new corn product, corn fodder, and shredded corn.

	Water.	Protein.	Fat.	Nitrogen-free extract.	Crude fiber.	Ash.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
New corn product	9.22	6.38	2.84	48.86	28.70	4.00
Corn fodder	9.80	3.94	2.42	46.16	33.18	4.50
Shredded corn fodder	20.10	4.31	2.37	40.33	28.29	4.60

The new corn product and the corn fodder were both dried artificially, so that they contained considerably less water than is ordinarily present in corn fodder.

The digestibility of the new corn product was compared with that of ground corn fodder, shredded corn fodder, and corn blades (leaves) and husks. The corn fodder was ground so as to be in about the same mechanical condition as the new corn product. The materials were fed to steers, and the proportion of each constituent was found to be as follows:

Digestibility of new corn product, corn fodder, and corn blades.

	Dry matter.	Protein.	Fat.	Nitrogen-free extract.	Crude fiber.	Ash.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
New corn product	63.5	59,7	82.8	65.8	60.5	48.7
Shredded corn fodder	58.6	38.2	73.2	57.3	67.1	29.3
Ground corn fodder	53.2	35.0	77.5	54.0	55.9	26.9
Corn blades and husks	64.6	47.7	58.1	66.4	72.9	22.6

It will be noticed that the new corn product was considerably more digestible than either shredded corn fodder, finely ground corn fodder, or corn blades and husks. As compared with the average figures for timothy hay when fed to cattle, the new corn product was found to be considerably more digestible than that material. The author says, "The results given in the above tables prove the new corn product to be a valuable cattle food, and in no sense should it be considered a waste product. The results not only show this material to be valuable, but in every respect show it to be superior to the shredded corn fodder or the entire plant in its natural condition."

The digestibility of the new corn product was also compared with that of timothy hay with horses. Here again the new corn product was found to be considerably more digestible.

A fattening experiment was made with steers, in which the new corn product was compared with corn blades, feeding a constant grain mixture with each. The steers on the new corn product gained 428 pounds in 60 days, or 3.57 pounds per head daily, while those on the corn blades gained 403 pounds, or an average of 3.36 pounds per head daily.

The new corn product was mixed with the grain. It was eaten with relish by the stock, and there was no waste. The cattle would lie down and chew their cud as naturally as when fed hay or in the pasture.

Later experiments were made with horses, in which the new corn product was compared with timothy hay, feeding ground oats in both cases. "Both rations maintained the animals in their normal condition, but there was considerably less eaten when on the new corn-product ration." This would be expected from the greater digestibility of the latter. Other trials were made in which the animals were worked. Here also it was found a satisfactory substitute for hay. In all, nine different horses were fed on rations with the new corn product. The author concludes that "the fact that the horses ate this feed continuously for five months and relished it more at the end than at the beginning, * * * together with the testimony of the weights, is sufficient data for concluding that the new corn product is a good food for horses and can replace hay for that purpose."

Satisfactory trials have also been made in feeding this material to cows and pigs. The animals take to it readily, seem fond of it, and eat it up clean without any waste.

Chemical analyses and digestion experiments made by the New York State Station go to show "that the new corn product has no materially increased value over well-cured and well-prepared corn fodder."

This work is interesting and useful, not only as showing the value of this particular new by-product of corn stover, but in a broader sense as indicating the great value of corn stover when it is rendered palatable to stock. It may be that the chief advantage of the new material lies in its mechanical condition, making it convenient to handle and to mix with other feed, and resulting in a more economical use of it by animals.

In feeding whole-corn fodder their is a large waste and the uneaten parts get into the manure and make it difficult to handle. The use of the corn shredder has removed these objections in large degree.

It is calculated from the statistical reports of this Department that the corn-stover crop of the United States in 1897 was nearly 80,000,000 tons, as compared with the hay crop of 60,665,000 tons. This corn stover would contain about 30,000,000 tons of food materials actually digestible by animals, including over 1,500,000 tons of protein, 27,000,000 tons of carbohydrates, and nearly 500,000 tons of fat. These figures are almost too large for comprehension. They mean that the corn-stover crop of the country contains nearly or quite as much digestible food materials as the hay crop. Throughout the corn-raising sections there is a very large and in some cases an almost total waste of this material. Anything, therefore, which will lead to a greater and more profitable utilization of corn stover will be of immense benefit to farmers in the corn-growing sections.

THE FEEDING VALUE OF SUGAR BEETS.

Sugar beets are being widely grown in the United States with a view to determining the localities in which they can be produced of sufficiently high quality to warrant the establishment of beet-sugar factories. It is not probable that factories will be built in all the localities where experiment shows that beets of high quality can be grown, and even in those localities where factories are established there will sometimes be a surplus of beets, which can not be disposed of to the factory. In such cases it is important to find some profitable use for the beets on the farm. Sugar beets, like other root crops, make an excellent addition to foods for cattle, sheep, and pigs. They are succulent and nutritious, keep well over winter, and form a welcome addition to the dry food of stock, keeping the animals in good health and maintaining the flow of milk.

The following table shows the food constituents in sugar beets as compared with other roots and with some of the more common feeding stuffs:

Food constituents of sugar beets and other feeding stuffs.

	Water.	Protein.	Fat.	Nitrogen-free extract.	Fiber.	Ash.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Sugar beets	86.5	1.8	0.1	9.8	0.9	0.9
Turnips	90.5	1.1	.2	6.2	1.2	.8
Mangel-wurzels	90.9	1.4	.2	5.5	.9	1.1
Ruta-bagas	88.6	1.2	.2	7.5	1.3	1.2
Corn fodder (whole plant)	79.3	1.8	.5	12.2	5.0	1.2
Corn silage	79.1	1.7	.8	11.0	6.0	1.4
Timothy hay	13.2	5.9	2.5	45.0	29.0	4.4

This table shows that as far as chemical composition is concerned sugar beets are somewhat richer than other common root crops, although experiments have indicated that all the common root crops are equally valuable as food for animals if equally palatable. The beets are not so rich in total food constituents as green corn fodder and silage, but it must be borne in mind that the beets are practically completely digestible, while only from two-thirds to three-fourths of the dry matter of corn fodder and silage is digestible.

The feeding value of sugar beets has been demonstrated in experiments at many of the stations. At the Wyoming Station sugar beets and alfalfa hay and grain and alfalfa hay were compared during the winter on steers and sheep, with the result that the animals fed sugar beets and hay gave better returns than those fed grain and hay or hay alone. In these experiments the steers were fed 14 pounds of sugar beets per head per day and all the hay they would eat.

Sugar beets, if fed in excessive amounts, may induce scouring. Extended experiments in Denmark have indicated that roots of any kind should not constitute more than 40 per cent of the ration of pigs. It is probable that this proportion should not be exceeded with other animals, although larger proportions have been fed to cows without injurious effects. Roots give best results when fed with grain or other concentrated food. As the above analyses show, beets contain little protein (nitrogenous matter). In order, therefore, to furnish a well-balanced ration they should be combined with some more nitrogenous food, such as wheat bran, peas, beans, oil meal, gluten meal, etc. The importance of thus providing a well-balanced ration was clearly demonstrated in the Wyoming Station experiments above referred to. In these experiments "the best balanced ration gave the best returns in each case."[1]

SALT-MARSH HAY.

In certain parts of the country, especially along the New England coast, there are extensive salt marshes which yield an abundant growth of the coarser grasses, locally known as "black grass, fox grass, branch grass, blue grass (variety of redtop), cove hay, salt hay mixture, and flat sage."[2] These grasses are cut and used as feed to a considerable extent in some localties, but no accurate experiments had been made to determine the actual feeding value of the different kinds of grasses until the Massachusetts Hatch Station undertook this work, although the Connecticut Station has made very complete chemical analyses of them.

In the experiments of the Massachusetts Station "the hays were analyzed, their digestibilities were determined by the aid of sheep, and their effects upon the quantity, as well as their influence upon the quality, of both milk and butter were carefully noted."

The following table shows the composition of different salt-marsh hays as compared with average meadow hay:

Composition of salt-marsh hays.

Kind of hay.	Water.	Protein.	Fat.	Nitrogen-free extract.	Ash.	Potash.	Phosphoric acid.	Nitrogen.
	Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
Black grass (*Juncus gerardi*)	16.00	7.32	2.08	43.89	6.60	(*a*)	(*a*)	(*a*)
Fox grass (*Spartina patens*)	17.00	7.27	2.06	45.07	6.22	0.92	0.18	1.20
Branch grass (*Distichlis spicata*)	21.00	6.22	2.22	43.46	6.20	.85	.18	1.00
Cove mixture (redtop and black grass)	18.00	7.23	1.72	44.54	5.90	(*a*)	(*a*)	(*a*)
Salt-hay mixture (branch grass, fox grass, and flat sage)	16.00	5.44	2.10	45.57	8.40	(*a*)	(*a*)	(*a*)
Flat sage (*Spartina stricta maritima* var.?)	17.00	6.49	2.41	41.32	8.12	1.10	.31	1.00
Redtop (*Agrostis vulgaris*)	13.00	6.78	1.58	44.85	5.62	(*a*)	(*a*)	(*a*)
Average meadow hay of mixed grasses ("English" hay)	13.00	6.56	2.15	42.17	4.25	1.50	29	1.00

a Not determined.

The table shows that the salt-marsh hays differ but little in chemical composition from average meadow hay. They contain about the same amount of protein, less fiber, and a little more nitrogen-free extract

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[1] For information regarding the compounding of rations for farm animals see Farmers' Bulletin No. 22 of this Department.

[2] For a discussion of the grasses of the salt marshes see Yearbook of this Department for 1895, p. 325.

(which consists principally of carbohydrates—starch, sugar, etc.). They also contain a little more ash, the excess of the latter being due to salt.

"The same amount of nitrogen was found as in English hay,[1] and two-thirds as much phosphoric acid and potash."

From the digestion experiments made by the station it was found that the following percentages of the different constituents of the various hays were digestible:

Coefficient of digestibility of salt-marsh hays.

Kind of hay.	Protein.	Fat.	Nitrogen-free extract.	Fiber.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
Black grass (*Juncus gerardi*)	54	46	49	57
Fox grass (*Spartina patens*)	59	36	53	57
Branch grass (*Distichlis spicata*)	52	37	46	25
Cove mixture (redtop and black grass)	48	40	53	60
Salt-hay mixture (branch grass, fox grass, and flat sage)	42	28	52	58
Flat sage (*Spartina stricta maritima* var.?)	52	36	55	60
Redtop (*Agrostis vulgaris*)	37	49	46	56
Average meadow hay of mixed grasses ("English" hay)	54	40	56	58

Salt hay, cut when in blossom and well cured, contains rather less digestible matter than average English hay cut under similar conditions. * * * [It has] from 10 to 18 per cent less feeding value than average English hay.

When fed in combination with grain and corn silage * * * the salt-hay rations produced [as a rule] from 2 to 5 per cent less milk and butter than did an equal amount of English hay similarly combined. * * *

When fed directly after milking no objectionable flavor could be detected in the milk or butter. It is possible that if these hays were cut very soon after being covered by the tide they would then produce a disagreeable flavor. * * *

The salt-hay rations produced milk with a trifle less percentage of fat than did the English hay ration. The difference is so slight as to be of no practical importance.

Because of the lower market price for salt hays as compared with English hay, daily rations containing 10 to 12 pounds of salt hay produced milk and butter from 10 to 20 per cent cheaper than rations containing an equal amount of English hay.

When there is a good market for English hay it is undoubtedly wise to sell it and feed salt hay in combination with corn silage as a substitute. One bushel of corn silage and 12 pounds of salt hay make a good daily coarse-fodder ration. If corn silage is not at hand, equal amounts of salt and English or pea and oat hay can compose the roughage ration. Any of the following grain mixtures may be fed in connection with the coarse fodders for complete daily rations:

I.

50 pounds cotton-seed meal,
100 pounds gluten feed,
100 pounds corn meal.
Mix and feed 5 to 7 quarts daily.

II.

100 pounds gluten meal,
100 pounds wheat bran.
Mix and feed 8 to 9 quarts daily.

III.

50 pounds cotton-seed meal,
100 pounds gluten feed,
100 pounds wheat bran.
Mix and feed 7 to 9 quarts daily.

IV.

100 pounds corn meal,
75 pounds gluten or cotton-seed meal.
Mix and feed 5 to 6 quarts daily.

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[1] Meadow hay, of mixed grasses.

The economy of the above different grain rations will depend on the local cost of the different feed stuffs.

It must be remembered that the value of salt hay is decidedly influenced by the time of cutting, and by the condition of the weather during the time of cutting and for a few weeks immediately after. A good deal of the salt hay cut would fall considerably below the value given it above because of late cutting and bad weather.

FORAGE CROPS FOR PIGS.

It is the opinion of many well-informed agriculturists that a much larger number of pigs may be profitably raised in the Southern States than is done at present. Generally speaking, there is an abundance of corn available; suitable forage crops are, however, required in addition. Peanuts and cowpeas furnish succulent food which contains considerable quantities of protein. While sweet potatoes contain only a small amount of protein, the content of carbohydrates is high and they may be easily raised, giving a comparatively certain and abundant crop.

Experiments were recently made at the Alabama College Station on the value of the above-named crops as food for pigs. Immediately after weaning, 6 Poland-China pigs were hurdled on a field of Spanish peanuts and given some shelled corn in addition. The peanuts were eaten readily, and as long as the vines remained green the leaves were eaten also. The yield of peanuts was at the rate of 62.6 bushels per acre. In the six weeks of the experiment the pigs consumed 373 pounds of shelled corn besides the peanuts and some foliage from 7,673 square feet, and gained 196.4 pounds—that is, 1.4 pounds of peanuts and 1.9 pounds of corn, together with an unknown quantity of peanut foliage, were consumed per pound of gain. Valuing the corn at 40 cents per bushel and pork at 3 cents per pound, the profit from the peanuts was at the rate of $18.34 per acre. The peanuts were raised on poor sandy upland which, in the investigator's opinion, would not have produced over 200 pounds of lint cotton per acre, worth from $10 to $12. The expense of cultivating the peanuts was less than for a similar area of cotton, and in addition the soil was benefited by the manure and the peanut vines.

Other tests were made, including one in which unhulled peanuts and corn meal were compared. When fed to pigs in pens only 2.8 pounds of unhulled Spanish peanuts were required to produce a pound of gain. In other words, there was a return of 9 pounds of pork, worth 27 cents, from a bushel of peanuts. The general conclusion was drawn that under ordinary circumstances an acre of peanuts supplemented by 37.8 bushels of corn produced 1,426 pounds of pork.

Young pigs pastured on nearly mature cowpeas and supplied with some corn in addition gained nearly three times as much in weight as similar pigs fed exclusively on corn. Deducting the value of the corn fed, the cowpeas returned in the form of pork $10.65 per acre.

Pigs confined in pens and fed ground cowpeas and corn gained more rapidly in weight than pigs fed corn alone. In effect 5.28 pounds of the mixed feed were equivalent to 8.06 pounds of corn alone.

Sweet potatoes and corn meal were also compared. Three pounds of sweet potatoes proved decidedly inferior to 1 pound of corn. It was calculated that in the form of pork the sweet potatoes returned only 13 cents per bushel.

This does not imply that sweet potatoes can not be profitably employed as food for pigs. But a profit is possible only by saving the expense of harvesting, the heaviest single item of expense in sweet-potato culture. If the pigs do the rooting the sweet potato is doubtless a cheaper food than corn on some sandy soils that yield ten to fifteen times as many bushels of sweet potatoes as of corn. The vines are also valuable as food for pigs.

The value of sweet potatoes will be enhanced by feeding with them a liberal allowance of cowpeas or peanuts, which supply the nitrogenous material in which the sweet potato is deficient.

The effect of the foods tested on the quality of the pork, more especially on the melting point of the lard, was noted. Cowpeas fed with corn had no injurious effect. Peanuts when fed with corn softened the pork and lard decidedly, and this effect was still more noticeable when the peanuts were fed alone. The softening effect of peanuts was not corrected by feeding corn exclusively for a month before slaughtering. The pork, however, had an unusually good flavor.

For the results of similar work elsewhere see Experiment Station Work—I (Farmers' Bul. 56 of the Department).

GROUND GRAIN V. WHOLE GRAIN FOR CHICKS.

The New York State Station has recently reported experiments made to determine whether it will pay to grind grain for poultry.

The first experiments were begun with two lots of 22 chicks each, one lot being fed "all its grain finely ground, the basis of the ration being a mixture of two parts by weight of corn meal, two parts wheat bran, and one part each of wheat middlings, old-process linseed meal, and ground oats. This was supplemented by skim milk, dried blood, and additional amounts daily of corn meal and ground oats. The grain fed [the other lot] was either whole or cracked and consisted of oats, wheat, corn, and barley. Skim milk, fresh-cut bone, and dried blood were fed in addition."

At the end of 12 weeks "the cockerels among these chicks were caponized and fed these contrasted rations during the winter, 12 capons in each lot being fed for 4 months and 8 continued nearly 7 months. * * * Two other lots of capons from chicks raised by hens and treated alike until caponized were fed these contrasted rations for about 5 months.

"The ground-grain ration proved considerably more profitable than the whole-grain ration with the growing chicks; and the same was true of capons of equal weight from these chicks and from others of equal weight and age fed alike before caponizing. No difference was noticed in health or vigor of chicks or capons fed either ration, but all made good gains and returned a fair margin of profit at the ordinary prices."

SKIM MILK FOR YOUNG CHICKENS.

Skim milk is a farm product whose food value is not fully appreciated. It is not generally realized that milk loses little in actual food value by skimming. It is true that most of the fat is removed in the cream, but the most valuable food constituents—i. e., the nitrogenous substances—are left behind in the skim milk. Skim milk not only contains much nutritive material, but this material is in a form which is, as a rule, easily digested. It is not only healthful, nutritious food for man, but it may be fed to calves, pigs, and chickens with excellent results. Its composition is such that it may be substituted for part of the grain food, especially corn, of these animals with benefit and profit.

The Indiana Station has recently made some interesting experiments on the use of skim milk for young chickens. Two uniform lots (4 to 6 weeks old) of 10 chickens each (5 Plymouth Rocks and 5 Houdans) were fed from July 11 to September 5, under identical conditions except that one lot received in addition to the food given the other all the skim milk they would drink. "Both lots were given all they would eat of a mixed food consisting of two parts crushed corn, one part bran, and one part ground oats. They were fed three times a day, except on Sundays, when an increased amount of food was given at the morning and evening meal. * * * Both lots were also given all they would consume of cracked bone, cabbage, lettuce, and water of which no record was kept."

It was found that the lot receiving skim milk ate more of the mixed food and made a more rapid and satisfactory gain than the lot which did not receive skim milk. Milk-fed chickens made an average weekly gain of 4.46 ounces, those receiving no milk 2.62 ounces. The most rapid increase in weight occurred at those periods when the largest amounts of skim milk were consumed. The skim milk is considered "especially valuable as a food for young chickens during the hot dry weather and becomes of less importance as the chickens grow older and the weather becomes cooler."

The vessels in which the skim milk is fed should be scalded frequently to keep them clean and wholesome.

BY-PRODUCTS OF THE DAIRY.[1]

The profitable disposal of the by-products of the dairy, both at the factory and on the farm, is a matter worthy of the most serious consideration. Of these by-products skim milk is the most important, both on account of its abundance and its high food value (see above). The Utah Station has recently published the results of some interesting experiments on the utilization of skim milk in the feeding of pigs and calves.

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[1] For a full discussion of this subject see Yearbook of the Department for 1897, p. 509.

Feeding skim milk to pigs.—It is a common practice at creameries "to feed hogs on milk or whey alone, and where grain is fed it is given only to finish the hog for market. This method of management does not appear to be successful, for it generally takes the whole season to get one crop of hogs ready for the market; besides, in many instances, it results in too high a death rate among the hogs to be at all profitable."

In the station experiments with pigs, which extended over several years and covered all seasons of the year, a study was made of "the economy of feeding milk alone and milk in combination with grain as compared with feeding grain alone." The grain fed was barley and bran (half and half), followed by ground corn and wheat (one to one), in the first experiment; equal parts of wheat and bran in the second, third, and fourth; ground wheat in the fifth; and equal parts of bran and corn meal in the sixth and seventh. There was no attempt, however, "to compare the relative value of the different varieties of grain when fed in combination with milk."

When milk and grain were fed in combination the milk was mixed with the grain before feeding, making a slop. The milk fed was sometimes fresh and sometimes sour, but never old. It was found to be impossible to get uniformity in this matter. Practically, however, it will not vitiate the results; it may even add value to them, as it would approach nearer to what the farmers and dairymen have to feed. When the hogs were fed grain alone, water was added to make a slop of similar consistency to that given the hogs fed on milk and grain. The hogs at all times had access to pure water, and a supply of charcoal and ashes was always kept in the pens.

The results of the experiments clearly prove that skim milk when fed in combination with grain makes a very valuable food for hogs at all periods of their growth, but particularly so during the earlier stages. Thus combined it makes a much more economical ration for hogs than either milk alone or grain alone. When fed in combination with grain, skim milk had 63 per cent greater feeding value than it had when fed alone, 100 pounds of skim milk taking the place of 23.2 pounds of grain in the former case and 14.2 pounds in the latter. Not only was the gain greater but it was more rapid in case of hogs fed on the milk and grain ration than in case of either those fed on milk alone or on grain alone. The time required to make 100 pounds of gain was 79 days for the hogs fed on milk and grain, 116 days for those fed on grain alone, and 147 days when the food was milk alone. When the skim milk and grain were fed in the proportion of 3 pounds or less of skim milk to 1 pound of grain the return for the skim milk was greater than when a larger proportion was fed. Hogs fed on milk alone gained very slowly and did not keep in good health. In some cases they were off their feed so frequently that a change of feed had to be made. The milk-and-grain-fed hogs, however, without exception, kept in good health. Young hogs fed on grain alone did not do well and appeared to make poor use of the food they ate. Hogs did much better on milk alone or grain alone when on pasture than when similarly fed in small pens. On the other hand, however, the hogs fed milk and grain in combination did better in the pens.

These experiments showed, further, that the appetite of the hogs and the palatability of the food seemed to have a very decided effect upon the rapidity and economy of the gain, "and that young hogs are in every way the more economical producers of pork. The hogs fed milk and grain required 62 per cent more to grow a pound of live weight when they weighed from 200 to 255 pounds than they did when they weighed from 38 to 100 pounds, and for those hogs fed grain alone the difference in favor of the smaller weight was 56 per cent."

Feeding skim milk to calves.—The experiments with calves at the Utah Station have likewise extended over several years (4).

The calves were in every case separated from the cow by the time they were twelve hours old. For the first 7 or 10 days the calves were fed the whole milk from the cow, some of the calves being fed twice and some three times a day. The milk was fed warm from the cow and the amount given was about 16 to 18 pounds per day. * * * When the calves were fed on whole milk it was gradually increased as they got older, till 20 to 22 pounds were fed per day at a month old, when the calves were disposed of.

Those calves which received skim milk were fed as follows: For the first 7 to 10 days of its life the calf got the whole milk from the cow; then skim milk was gradually substituted till at the end of one week, or when the calves were 14 to 17 days old, the calf got half skim milk and half whole milk. At the end of the next week the ration was three-fourths skim milk and one-fourth whole milk, and at the end of another week, or by the time the calf was 4 to 5½ weeks old, the ration consisted of all skim milk. If, however, the calf was not doing as well as we would like, a little whole milk was continued for another week or two. The amount of skim milk was gradually increased as the calf got older, but the most fed in any one day was from 25 to 27 pounds. The skim-milk ration was kept up till the calves were 5 to 6 months old, but as they increased in age they had what water they could drink in addition to the milk. We have found it to be of the utmost importance to make all changes of feed gradually, so as not to disturb the digestion of the young calf.

Separator skim milk was used, and in every instance it was fed fresh. To prevent the milk from souring, it was boiled by having steam turned into it (which diluted it about 8 per cent), and then it was cooled to about 60° F. in summer and to about 40° F. in winter. When treated in this way the milk would keep fresh about 3 or 4 days in summer and about a week during the winter.

The skim milk given to the young calves was always fed warm, from 80° to 100° F. The cold milk, we learned from a little experience, generally produced indigestion, with the resulting scours. The milk, however, should not be hot. Our method of warming the milk was by the use of a lamp stove, only a few minutes being required to heat a pailful of milk.

As soon as the calves would eat it, a little grain was given to them. Chopped grain was used, and it was fed dry in a box and not put into the milk. No tests were made of the value of the different kinds of grain, though quite a variety of grains was fed—wheat and bran, barley and bran, barley, peas and bran, corn and bran, and corn. No particular difference was noted in the efficacy of either. The calves usually started to eat a little grain when from 3 to 5 weeks of age. If, when first given to them, they did not eat the grain up clean, it was always renewed in 2 or 3 days. The cows or hogs never refused what the calves left.

After the calves were 2 or 3 weeks old a little hay—as a rule, lucern—was kept before them and renewed frequently; they soon learned to eat it.

By following the method above outlined, feeding the milk warm and not in too large quantities and making all changes of food gradually, we have managed to keep the calves in good health, and have been troubled but little with scours, which results from indigestion. The few cases that we have had yielded readily to treatment. A small handful of flour stirred in the milk we have found excellent as a corrective; or, better still, two teaspoonfuls of rennet extract in the milk for a few days. Our experience teaches that indigestion is something that must not be neglected or the calf may be permanently injured.

The results show that calves may be raised very profitably on skim milk when it is properly fed. While from the standpoint of gain in live weight and quality of meat whole milk is a better food for calves than skim milk, it makes too expensive a ration to be profitably fed. In these experiments the gain in live weight of the calves at 4 cents per pound returned only 10.7 cents per pound for the butter fat fed in the milk, and at 3 cents per pound only 8 cents per pound. While the calves whose rations were composed largely of skim milk gained one-half pound less per day than those fed on whole milk, they made practically the same gain in live weight per pound of dry matter consumed. In other words, they made just as good use of the food consumed.

The calves fed whole milk alone gave a greater proportion of dressed meat to live weight than did those fed on skim milk, and also gave more fat on the carcass.

Young calves up to 3½ months of age required less milk and less dry matter to each pound of gain than did the hogs. When the calves were 5 and 6 months old, however, more dry matter was required, but at least half of it was hay.

Fully as large financial returns were obtained for the skim milk when fed to calves as when fed to hogs. With the gain in live weight at 4 cents per pound the calves returned 22 cents per 100 pounds for the skim milk and the hogs 22.8 cents. If the gain in live weight was worth 3 cents per pound, the calves would return 5 cents per 100 pounds more for the milk than would the hogs.

In applying the above facts to actual farm practice it should not be forgotten that the results here given are probably the best that could be expected, while no account is taken of the cost of drawing the milk back to the farm, as would be necessary where the milk is sent to a factory, nor yet for caring for and feeding the hogs. As figured out under the best conditions, when a large number of hogs are handled, the labor cost of looking after them is about one-half cent for each 100 pounds of milk fed. On the farm, however, the cost, if it is reckoned at all, will be many times this, so that perhaps no more than one-half of the value here calculated could be given as the net returns for 100 pounds of skim milk. In handling a large number of hogs, too, it is doubtful if as good results would be obtained as there were with the small number fed at any one time in this experiment. However, our results show a possibility, and the above remarks in no way apply to or change the results obtained from a comparison of the different methods of feeding.

The remarks on the labor cost of feeding animals are equally as applicable to calf feeding as to hog feeding; though perhaps it would be more difficult to feed a large number of calves than a large number of hogs.

Another point to note is that the experiments answer only the question as to the value of the skim milk. Though whey was fed, our experiments were altogether too limited to compare its value with that of skim milk. Experiments conducted at other stations generally place the value of whey at one-half that of skim milk.

STRIPPER BUTTER.

The statement is often made, and recent experiments at the Oregon Station go to show, that cream rises imperfectly in milk from cows in advanced periods of lactation (stripper cows) and that it is difficult to obtain butter of good flavor from such milk.

The Iowa Station has investigated this subject, using milk from fresh cows and from those which had been in milk over six months (strippers). The milk from the two lots was creamed and churned separately. The results show that when the separator system was used the butter from the stripper milk was as good as that from the milk of the fresh cows.

Under a gravity system there may be some difference, as so many dairymen claim, and the following is a possible explanation: The fat globules, as is well known, are smaller in advanced periods of lactation, and when cream from such milk is raised by the gravity process more time is required for the cream to rise than when the milk is from fresh cows whose milk contains globules of much larger size. We have found that cream or milk when kept at a low temperature for some time develops a somewhat bitter flavor. There seems to be an organism which grows at that low temperature and which gives a flavor to the cream and to the butter. It is possible that this is why stripper milk is generally considered inferior for the production of butter.

As a means of overcoming these difficulties it is suggested that the stripper cows be given some food of a succulent nature which will increase the flow of milk and thus render it less viscous, and that a strong starter of sour milk be used with the cream.

THE CURD TEST IN CHEESE MAKING.

In order that cheese of a uniform standard of excellence may be made the milk supplied to a cheese factory must be of uniformly good quality. "Through carelessness, ignorance, or malice the milk is sometimes delivered to the factory in an imperfect condition. The cheese maker, in order to protect himself as well as the conscientious, painstaking patrons, must be able to accurately judge of the quality of the milk as it is brought to the factory. Especially in those sections where some form of a guarantee principle is in vogue, the cheese maker should possess the latest knowledge as to the best and most accurate methods that have been devised for the determination of the actual value of the raw material."

The Wisconsin Station describes in a recent bulletin[1] a method which enables the cheese maker to determine easily and accurately the cheese-making quality of the milk furnished by each patron. This method has been named the "Wisconsin curd test." The apparatus for this test resembles in some respects the Gerber milk-testing apparatus, and can be obtained of some dealers in dairy supplies. A home-made test, however, can be improvised which will give good results.

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[1] Bul. 67.

HOME-MADE TEST.

The apparatus for the test (see figs. 1 and 2) consists of a wash tub that is half filled with warm water, a set of pint fruit jars (C) for the different samples, a pipette (P) for measuring the rennet, and a case knife (K) for breaking the curd.

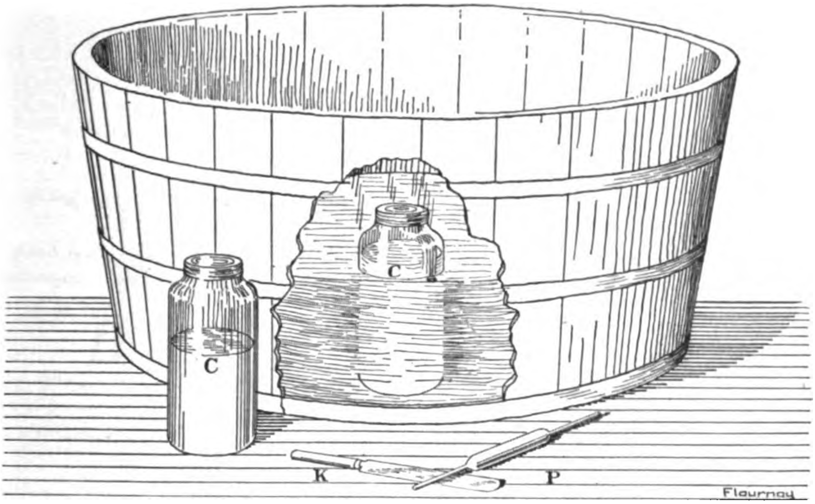

FIG. 1.—The home-made curd test: C, cans used to hold sample; P, pipette for measuring rennet; K, knife for breaking curd.

How to make a test.—To make a test fill a jar half full of milk. Set samples in the tub and fill the same half full of warm water. Usually water at 115° F. will raise the temperature of the milk to the desired point, viz, 98°. If the milk is very cold, care should be taken not to use too hot water, to prevent cracking the ja

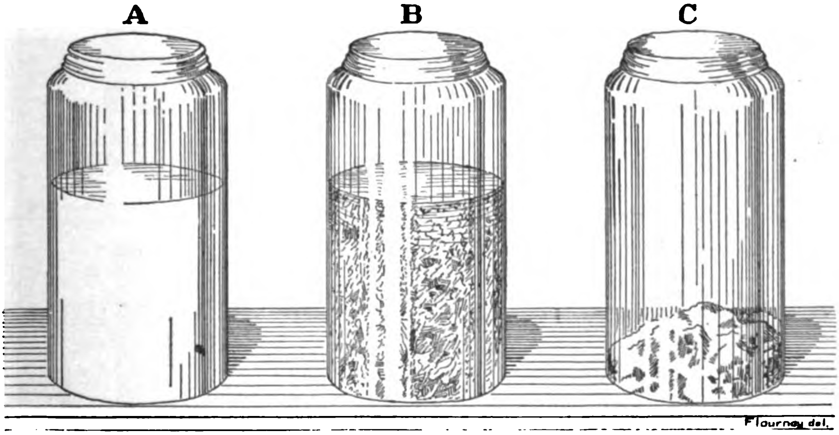

FIG. 2.—Different stages of home-made test: A, milk; B, broken curd in whey; C, matted curd.

When the temperature of the milk reaches 98° F. add to each sample, by means of a pipette, 10 drops of rennet extract and mix thoroughly. Allow the jars to remain undisturbed until milk is curdled, then break the curd into small particles by stirring with a case knife, in order to better expel the whey. In using thermometers for taking temperatures, or knife for cutting the curds, care should be taken to rinse after using in each sample, so as to prevent the transference of many organisms from one sample to another.

The whey should be poured off as soon as the curd settles to the bottom, this process being repeated at frequent intervals until the curd mats into a solid mass. This expels the excess of whey which contains the fermentable sugar, thereby simulating cheese conditions more closely. The temperature of the surrounding water should be maintained from six to eight hours, to favor a rapid development of the contained organisms.

This improvised apparatus will enable any cheese maker to use the test with satisfactory results, but time can be saved and greater convenience secured if apparatus is devised for the particular purpose in hand. When the curd test is in constant use some such apparatus as that described below will be well worth the expense.

IMPROVED CURD TEST.

The improved apparatus shown in figs. 3 and 4 has the following points of advantage over the improvised test already described:

(1) A water box with a close-fitting cover permits of a retention of the desired temperature for a much longer period of time than an open tub. This is important if the weather is cool.

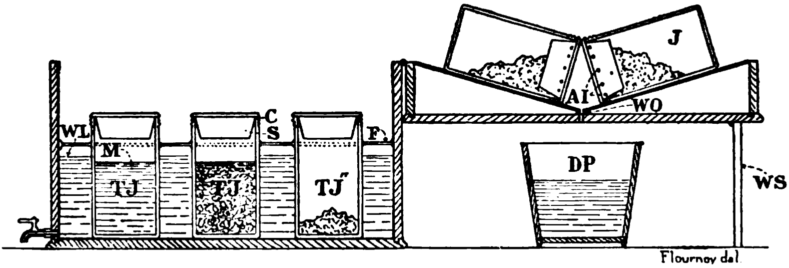

Fig. 3.—Section of improved curd test: TJ, TJ″. test jars showing different stages of test; WL water line; M, milk; F frame; WS, wire standard to support cover; AI, drain holes; WO, whey outlet; DP, drain pail.

(2) A faucet in the bottom allows the water to be drawn off and replaced with warm water without handling the bottles, thereby saving time and labor.

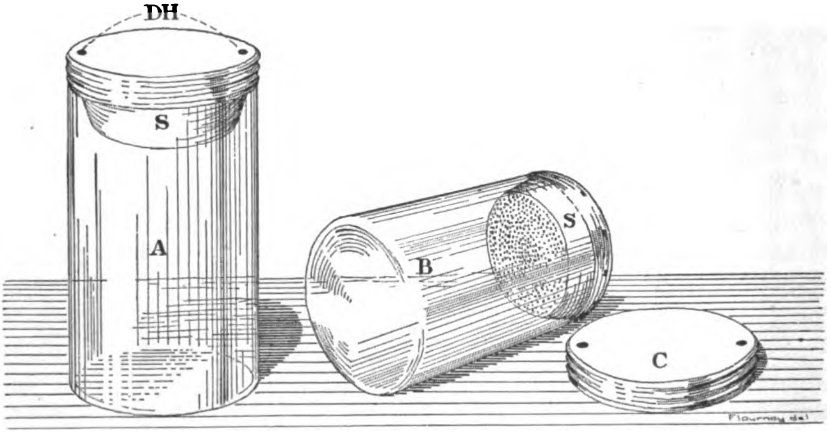

Fig. 4.—Improved test bottle: A, test bottle complete; S, sieve; DH, drain holes in cover; B, test bottle showing construction of cover; C, outer cover; S, sieve.

(3) A rack (F) holds the bottles (T J) in place; without this rack the bottles tip over easily in the water when the whey has been emptied.

(4) The bottles have a large top and straight sides, so that the curd can be more easily removed. The bottles are more easily cleaned on this account.

(5) The strainer (S) in the top enables the operator to place the bottle in an inclined position to let the whey drain out. The whey can thus be more quickly and completely removed. * * *

INTERPRETATION OF RESULTS.

If the milk contains no deleterious bacteria the curd when cut will present a firm, even texture, as shown in fig. 5. If gas-producing bacteria are present the texture of the curd will be more spongy, the cut surface showing a number of holes varying in size, depending upon the prevalence and gas-producing ability of the undesirable bacteria, as shown in figs. 6 and 7.

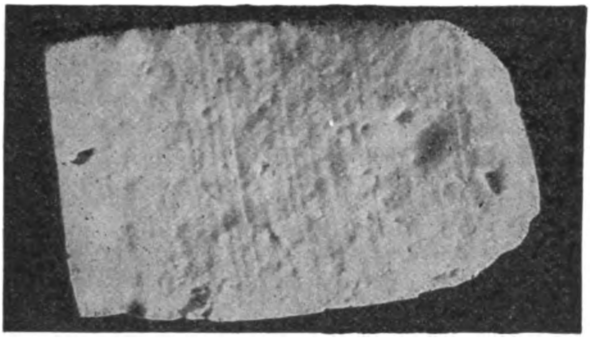

Fig. 5.—Curd from good milk. Large, irregular holes mechanical.

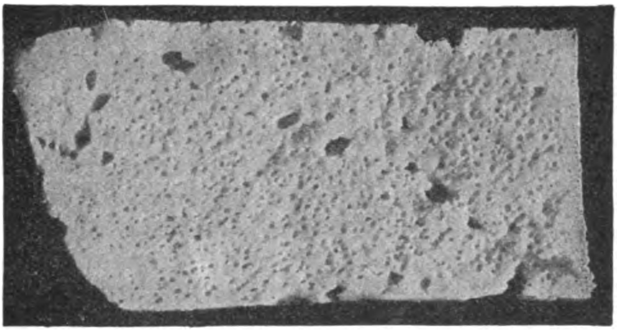

Fig. 6.—Curd from bad milk. Large, irregular holes mechanical, small pin holes due to gas.

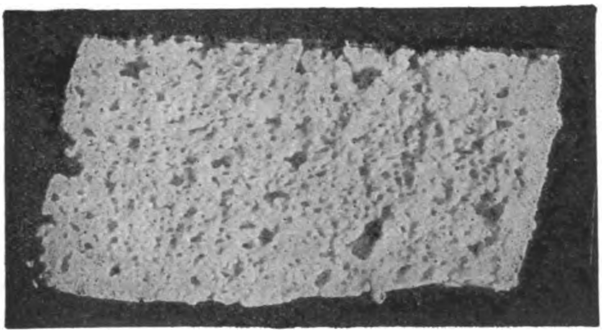

Fig. 7.—Floating curd from very bad milk. Condition reached by further development of fig. 6, or a greater number of gas-producing bacteria.

> Care should be taken to discriminate between purely mechanical holes that are formed by the failure of the curd to mat closely and those caused by the fermentation of gas. Mechanical holes are irregular in form and more variable in size, while holes formed by gas are circular in outline and more uniformly distributed throughout the whole mass of curd. * * *
>
> It should be borne in mind that the formation of gas is generally accompanied with the production of other decomposition products that possess more or less pronounced undesirable flavors and odors, and that the injury to the cheese is due to this more than to the mere mechanical presence of gas. It is also possible that taints may be produced by bacterial decomposition in cases where no gas is formed. * * * Those bacteria that find their way into the milk through the introduction of filth and dust are particularly prone to produce this change, and this type of fermentation is very often found during the summer months. In the curd test such milks are not condemned upon the texture of the curd, but upon the odor, which is more or less pronounced when the bottles are opened.

This test has been successfully used both at the station and in a number of factories in different parts of Wisconsin and has proved in the hands of the factory operator to be an effective means of detecting tainted milk, and has been "especially useful in helping to solve the controversies that arise in every factory between maker and patrons as to the presence and origin of tainted milks."

THE GAPE DISEASE OF CHICKENS.

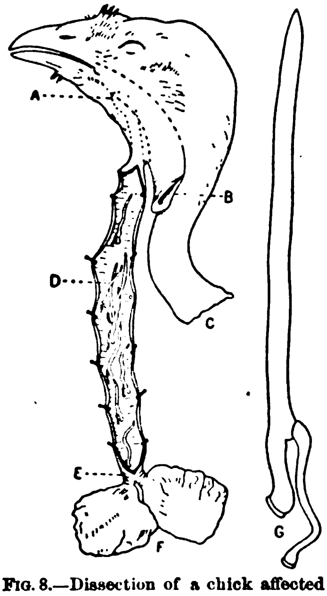

FIG. 8.—Dissection of a chick affected with gapes, the trachea pinned open: A, the glottis or opening through which air enters the trachea from the mouth; B, the cut end of the œsophagus; C, the cut neck; D, the open trachea with gapeworms attached to its wall; E, the bronchial or lung tubes, one for each long; F, the lungs; G, a pair of gapeworms, the small male being permanently attached to the female.

This common and destructive disease of chickens is due to the presence in the windpipe of the gapeworm, known to scientists as *Syngamus trachealis*. "These worms obstruct the passage of air to and from the lungs (fig. 8), and thus occasion the characteristic gasping movements of the suffering chicks." This disease has been carefully studied by the Kentucky Station. It was found that "the commonly recommended practice of introducing into the trachea a partly stripped feather, or a bluegrass top, and by a twisting motion dislodging and removing the worms does not seem to * * * be practicable for very young chicks. The trachea is so small and so easily injured that it is impossible to dislodge and remove all of the worms by such means. * * * Chicks generally recover without treatment when they are attacked after they are half grown, and hence fowls that might from their size be treated successfully with a feather do not require treatment of any sort. It is the very young chicks that suffer most, and the only remedial treatment in their case that seems to be successful is rubbing the neck from time to time with lard or vaseline, thoroughly mixed with a little turpentine (three parts of the lard or vaseline to one part of turpentine). This treatment should begin before the disease makes its appearance. It will not help a chick in the last stages of the disease. Pure turpentine will very quickly kill a chick when rubbed on the neck over the trachea."

A French scientist (Megnin) asserts that the use of pounded garlic with the usual food (one garlic bulb to ten birds daily), supplemented by special care in the use of only pure water, which is changed several times a day, has been found to completely eradicate gapes from pheasants. This is a simple treatment, and there is no apparent reason why it should not prove as effective with chickens as with pheasants.

Experiments by the Kentucky Station show that chickens contract the disease when allowed to run on soil which has become infested with the gapeworm or when fed earthworms, and "that keeping chicks on a plank floor for several weeks after they hatch will prevent the gapes. It is [probable] that the same result would be obtained by simply elevating an earthen floor above the surrounding level, so that it would not retain moisture. It must be remembered, though, that after the disease is established in a brood it will be conveyed from one to another through the medium of food and drink, and in such case a plank floor would not alone save it. In case the disease should be introduced by chicks which had contracted it elsewhere, the proper treatment would be to isolate affected individuals as soon as discovered and medicate the drinking water of the rest."

It has been claimed that hens may be infested with the gapeworm without showing any evidence of the fact, and may thus be the means of transmitting the disease to the chicks. If this be true, it becomes important to see that the brood hen is free from the disease before the chicks are hatched.

EXPLANATION OF TERMS.

TERMS USED IN DISCUSSING FERTILIZERS.

Complete fertilizer is one which contains the three essential fertilizing constituents, i. e., nitrogen, phosphoric acid, and potash.

Nitrogen exists in fertilizers in three distinct forms, viz, as organic matter, as ammonia, and as nitrates. It is the most expensive fertilizing ingredient.

Organic nitrogen is nitrogen in combination with other elements either as vegetable or animal matter. The more valuable sources are dried blood, dried meat, tankage, dried fish, and cotton-seed meal.

Ammonia is a compound of nitrogen more readily available to plants than organic nitrogen. The most common form is sulphate of ammonia, or ammonium sulphate. It is one of the first products that results from the decay of vegetable or animal substances.

Nitrates furnish the most readily available forms of nitrogen. The most common are nitrate of soda and nitrate of potash (saltpeter).

Phosphoric acid, one of the essential fertilizing ingredients, is derived from materials called phosphates. It does not exist alone, but in combination, most commonly as phosphate of lime in the form of bones, rock phosphate, and phosphatic slag. Phosphoric acid occurs in fertilizers in three forms—soluble, reverted, and insoluble phosphoric acid.

Superphosphate.—In natural or untreated phosphates the phosphoric acid is insoluble in water and not readily available to plants. Superphosphate is prepared from these by grinding and treating with sulphuric acid, which makes the phosphoric acid more available to plants. Superphosphates are sometimes called acid phosphates.

Potash, as a constituent of fertilizers, exists in a number of forms, but chiefly as chlorid or muriate and as sulphate. All forms are freely soluble in water and are believed to be nearly, if not quite, equally available, but it has been found that the chlorids may injuriously affect the quality of tobacco, potatoes, and certain other crops. The chief sources of potash are the potash salts from Stassfurt, Germany—kainit, sylvinit, muriate of potash, sulphate of potash, and sulphate of potash and magnesia. Wood ashes and cotton-hull ashes are also sources of potash.

TERMS USED IN DISCUSSING FOODS AND FEEDING STUFFS.

Water is contained in all foods and feeding stuffs. The amount varies from 8 to 15 pounds per 100 pounds of such dry materials as hay, straw, or grain to 80 pounds in silage and 90 pounds in some roots.

Dry matter is the portion remaining after removing or excluding the water.

Ash is what is left when the combustible part of a feeding stuff is burned away. It consists chiefly of lime, magnesia, potash, soda, iron, chlorin, and carbonic, sulphuric, and phosphoric acids, and is used largely in making bones. Part of the ash constituents of the food is stored up in the animal's body; the rest is voided in the urine and manure.

Protein (nitrogenous matter) is the name of a group of substances containing nitrogen. Protein furnishes the materials for the lean flesh, blood, skin, muscles, tendons, nerves, hair, horns, wool, casein of milk, albumen of eggs, etc., and is one of the most important constituents of feeding stuffs.

Gluten is the name given to one of the most important of the nitrogenous substances classed together under the general term "protein." "Wheat gum," obtained by carefully chewing wheat, is a familiar example. It is the gluten of flour that gives consistency to the dough.

Carbohydrates.—The nitrogen-free extract and fiber are often classed together under the name of carbohydrates. The carbohydrates form the largest part of all vegetable foods. They are either stored up as fat or burned in the body to produce heat and energy. The most common and important carbohydrates are sugar and starch.

Fiber, sometimes called crude cellulose, is the framework of plants, and is, as a rule, the most indigestible constituent of feeding stuffs. The coarse fodders, such as hay and straw, contain a much larger proportion of fiber than the grains, oil cakes, etc.

Nitrogen-free extract includes starch, sugar, gums, and the like, and forms an important part of all feeding stuffs, but especially of most grains.

Fat, or the materials dissolved from a feeding stuff by ether, is a substance of mixed character, and may include, besides real fats, wax, the green coloring matter of plants, etc. The fat of food is either stored up in the body as fat or burned to furnish heat and energy.

MISCELLANEOUS TERMS.

Micro-organism, or microscopic organism, is a plant or animal too small to be seen without the aid of a compound microscope.

Bacterium (plural, **Bacteria**) is the name applied in common to a number of different or closely related microscopic organisms, all of which consist of single short cylindrical or elliptical cells or two such cells joined end to end and capable of spontaneous movement. Many kinds of bacteria are harmful and cause diseases and other injurious effects, but many are beneficial. Among the latter are those which give aroma to tobacco and flavor to butter and cheese, and those which enable leguminous plants to use the free nitrogen of the air.

Culm.—The stem or straw of grains and grasses.

Node.—That part of the stem (usually somewhat enlarged and hardened, especially in grains and grasses) to which the leaves are attached.

Internode.—The part of the stem between the nodes.

Chlorophyll.—The green coloring matter of plants.

Lactation.—The formation or secretion of milk. The "period of lactation" as applied to cows means the length of time since calving that they have been giving milk.

FARMERS' BULLETINS.

The following is a list of the Farmers' Bulletins available for distribution, showing the number, title, and size in pages of each. Copies will be sent to any address on application to Senators, Representatives, and Delegates in Congress, or to the Secretary of Agriculture, Washington, D. C. The missing numbers have been discontinued, being superseded by later bulletins.

16. Leguminous Plants. Pp. 24.
21. Barnyard Manure. Pp. 32.
22. The Feeding of Farm Animals. Pp. 32.
24. Hog Cholera and Swine Plague. Pp. 16.
25. Peanuts: Culture and Uses. Pp. 24.
27. Flax for Seed and Fiber. Pp. 16.
28. Weeds: And How to Kill Them. Pp. 32.
29. Souring and Other Changes in Milk. Pp. 23.
30. Grape Diseases on the Pacific Coast. Pp. 15.
31. Alfalfa, or Lucern. Pp. 24.
32. Silos and Silage. Pp. 32.
33. Peach Growing for Market. Pp. 24.
34. Meats: Composition and Cooking. Pp 29.
35. Potato Culture. Pp. 24.
36. Cotton Seed and Its Products. Pp. 16.
37. Kafir Corn: Culture and Uses. Pp. 12.
38. Spraying for Fruit Diseases. Pp. 12.
39. Onion Culture. Pp. 31.
40. Farm Drainage. Pp. 24.
42. Facts About Milk. Pp. 29.
43. Sewage Disposal on the Farm. Pp. 20.
44. Commercial Fertilizers. Pp. 24.
45. Insects Injurious to Stored Grain. Pp. 24.
46. Irrigation in Humid Climates. Pp. 27.
47. Insects Affecting the Cotton Plant. Pp. 32.
48. The Manuring of Cotton. Pp. 16.
49. Sheep Feeding. Pp. 24.
50. Sorghum as a Forage Crop. Pp. 20.
51. Standard Varieties of Chickens. Pp. 48.
52. The Sugar Beet. Pp. 48.
53. How to Grow Mushrooms. Pp. 20.
54. Some Common Birds. Pp. 40.
55. The Dairy Herd. Pp. 24.
56. Experiment Station Work—I. Pp. 31.
57. Butter Making on the Farm. Pp. 16.
58. The Soy Bean as a Forage Crop. Pp. 24.
59. Bee Keeping. Pp. 32.
60. Methods of Curing Tobacco. Pp. 16.
61. Asparagus Culture. Pp. 40.
62. Marketing Farm Produce. Pp. 28.
63. Care of Milk on the Farm. Pp. 40.
64. Ducks and Geese. Pp. 48.
65. Experiment Station Work—II. Pp. 32.
66. Meadows and Pastures. Pp. 28.
67. Forestry for Farmers. Pp. 48.
68. The Black Rot of the Cabbage. Pp. 22.
69. Experiment Station Work—III. Pp. 32.
70. Insect Enemies of the Grape. Pp. 23.
71. Essentials in Beef Production. Pp. 24.
72. Cattle Ranges of the Southwest. Pp. 32.
73. Experiment Station Work—IV. Pp. 32.
74. Milk as Food. Pp. 39.
75. The Grain Smuts. Pp. 20.
76. Tomato Growing. Pp. 30.
77. The Liming of Soils. Pp. 19.
78. Experiment Station Work—V. Pp. 32.
79. Experiment Station Work—VI. Pp. 28.
80. The Peach Twig-borer. Pp. 16.
81. Corn Culture in the South. Pp. 24.
82. The Culture of Tobacco. Pp. 24.
83. Tobacco Soils. Pp. 23.
84. Experiment Station Work—VII. Pp. 32.
85. Fish as Food. Pp. 30.
86. Thirty Poisonous Plants. Pp. 32.
87. Experiment Station Work—VIII. Pp. 32.
88. Alkali Lands. Pp. 23.
89. Cowpeas. Pp. 16.
91. Potato Diseases and Treatment. Pp. 12.
92. Experiment Station Work—IX. Pp. 30.
93. Sugar as Food. Pp. 27.
94. The Vegetable Garden. Pp. 24.
95. Good Roads for Farmers. Pp. 47.
96. Raising Sheep for Mutton. Pp. 48.
97. Experiment Station Work—X. Pp. 32
98. Suggestions to Southern Farmers. Pp. 48.
99. Insect Enemies of Shade Trees. Pp. 30.
100. Hog Raising in the South. Pp. 40.
101. Millets. Pp. 28.
102. Southern Forage Plants. Pp. 48.
103. Experiment Station Work—XI. Pp. 32.
104. Notes on Frost. Pp. 24.
105. Experiment Station Work—XII. Pp. 32.
106. Breeds of Dairy Cattle. Pp. 48.
107. Experiment Station Work—XIII. Pp. 32.
108. Saltbushes. Pp. 20.
109. Farmers' Reading Courses. Pp. 20.
110. Rice Culture in the United States. Pp. 28.
111. Farmers' Interest in Good Seed. Pp. 24.
112. Bread and Bread Making. Pp. 39.
113. The Apple and How to Grow It. Pp. 32.
114. Experiment Station Work—XIV. Pp. 28.
115. Hop Culture in California. Pp. 27.
116. Irrigation in Fruit Growing. Pp. 48.
117. Sheep, Hogs, and Horses in the Northwest. Pp. 28.
118. Grape Growing in the South. Pp. 32.
119. Experiment Station Work—XV. Pp. 31.
120. Insects Affecting Tobacco. Pp. 32.
121. Beans, Peas, and other Legumes as Food. Pp. 32.
122. Experiment Station Work—XVI. Pp. 32.
123. Red Clover Seed: Information for Purchasers. Pp. 11.
124. Experiment Station Work—XVII. Pp. 32.
125. Protection of Food Products from Injurious Temperatures. Pp. 26.
126. Practical Suggestions for Farm Buildings. Pp. 48.
127. Important Insecticides. Pp. 42.
128. Eggs and their Uses as Food. Pp. 32.
129. Sweet Potatoes. Pp. 40.
130. The Mexican Cotton Boll Weevil. Pp. 30.
131. Household Test for Detection of Oleomargarine and Renovated Butter. Pp. 11.
132. Insect Enemies of Growing Wheat. Pp. 40
133. Experiment Station Work—XVIII. Pp. 32.
134. Tree Planting in Rural School Grounds. Pp. 38.
135. Sorghum Sirup Manufacture. Pp. 40.
136. Earth Roads. Pp. 24.
137. The Angora Goat. Pp. 48.
138. Irrigation in Field and Garden. Pp. 40.
139. Emmer: A Grain for the Semiarid Regions. Pp. 16.
140. Pineapple Growing. Pp. 48.
141. Poultry Raising on the Farm. Pp. 16.
142. The Nutritive and Economic Value of Food. Pp. 48.
143. The Conformation of Beef and Dairy Cattle. Pp. 44.
144. Experiment Station Work—XIX. Pp. 32.
145. Carbon Bisulphid as an Insecticide. Pp. 28.
146. Insecticides and Fungicides. Pp. 16.
147. Winter Forage Crops for the South. Pp. 36.
148. Celery Culture. Pp. 32.
149. Experiment Station Work—XX.
150. Clearing New Land.

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U. S. DEPARTMENT OF AGRICULTURE.

FARMERS' BULLETIN No. 85.

FISH AS FOOD.

BY

C. F. LANGWORTHY, Ph. D.,
Office of Experiment Stations.

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LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
OFFICE OF EXPERIMENT STATIONS,
Washington, D. C., October 31, 1898.

SIR: I have the honor to transmit herewith an article on fish as food, prepared by C. F. Langworthy, of this Office, under the supervision of Prof. W. O. Atwater, special agent in charge of nutrition investigations, in accordance with instructions given by the Director of this Office.

The article is largely based on the investigations of Professor Atwater on the chemical composition and nutritive values of food fishes and aquatic invertebrates, the results of which were published in the reports of the United States Fish Commission for 1880, 1883, and 1888. Other publications of the Fish Commission as well as reports of the New Jersey Experiment Stations (1888–1892) have been consulted, material from other authoritative sources has also been incorporated, and the practical application of scientific investigations regarding the food value of fish has been pointed out and illustrated. The publication of this article as a Farmers' Bulletin is respectfully recommended.

Respectfully,

A. C. TRUE,
Director.

HON. JAMES WILSON,
Secretary of Agriculture.

CONTENTS.

Page.

Introduction 7

Preparing fish for market 8

Nutritive value of fish 10

  Composition of fish 10

  Cost of protein and energy in fish and other food materials 18

  Digestibility of fish 19

Place of fish in the diet 21

  Preparing fish for the table 22

  Daily menus containing fish 23

Possible dangers from eating fish 28

FISH AS FOOD.

INTRODUCTION.

As ordinarily used, the term fish includes, besides the fish proper, many other water animals, as oysters, clams, and other mollusks; lobsters, crawfish, crabs and shrimps; and turtle and terrapin. The term sea food is often used to cover the whole group, or, more particularly, salt water food products as distinguished from those of fresh water.

Fish in one form or another is almost universally recognized as one of the important food materials, and enters to a greater or less extent into the diet of very many if not most American families. Few, however, have any adequate conception of the great importance of the fisheries of the United States and of the immense amount of nutritive material which is every year taken from the salt and fresh waters of this country. From recent data collected by the United States Fish Commission, it appears that more than 616,000,000 pounds of fish, crustaceans, etc., are annually taken from the waters of the New England States; over 596,000,000 pounds from the Middle Atlantic States; over 59,000,000 from the South Atlantic States; 84,000,000 from the Gulf States; 147,000,000 from the Pacific States, and 64,000,000 from Alaska. The products of the fisheries of the Great Lakes exceed 108,000,000 pounds annually and the interior fisheries 19,000,000 pounds. In the case of such products as clams, scallops, and oysters the weight of the edible portion only has been taken into account. The interior fisheries of Vermont are included with those of New England, the fisheries of New York and Pennsylvania on the Great Lakes with those of the Middle Atlantic States, and the fisheries of the east coast of Florida with those of the Gulf States. The data for the Great Lakes embrace only those States not having coast fisheries, but include the fisheries of the Ohio River for Ohio, Indiana, and Illinois. The figures for the interior States are confined to States not having coast or Great Lake fisheries. In addition, thousands of pounds of fish are annually caught by sportsmen, but statistics of the amount are not available.

The total weight of these products as they leave the hands of the fishermen is about 1,696,000,000 pounds, representing, as the value of the catch, $47,180,000. By the processes of canning, salting, smoking, and otherwise preserving, the value of the fish is very much increased.

Of the very large quantity of fish annually placed on the American market, the greater part is consumed at home, although a portion is prepared in various ways for export.

The preference for fresh-water or salt-water fish is a matter of individual taste. Both are, so far as known, equally wholesome. The market value of fish is affected by various conditions. Among these are the locality from which they come, the season in which they are taken, and the food on which they have grown. In general, it may be said that fish from clear, cold, or deep water are regarded as preferable to those from shallow or warm water, while fish taken in waters with a rocky or sandy bottom are preferable to those from water with a muddy bottom. Some fish, for instance shad, are at their best during the spawning season, while others should not be eaten during this period. Those fish which feed on small crustacea and other forms of animal and vegetable life, which are their natural food, are preferable to those living upon sewage and other matter which may contaminate the waters. (See p. 29.)

The mode of capture also affects the market value. Fish caught by the gills and allowed to die in the water by slow degrees, as is the case where gill nets are used, undergo decomposition very readily and are inferior for food. Fish are often landed alive and allowed to die slowly. This custom is not only inhumane, but lessens the value of the fish. It has been found that fish killed immediately after catching remain firm and bear shipment better than those allowed to die slowly. The quality of the fish is often injured by improper handling in the fishing boats before placing on the market. Improvement in chilling apparatus and in other lines have made it possible to bring fish to market from distant fishing grounds in good condition.

The flavor of oysters is affected more or less by the locality in which they have grown, those from certain regions being regarded as of very superior quality. The season of the year affects the market value of oysters, although it is noticeable that as methods of transportation and preservation improve, the oyster season becomes longer. This may also be said of lobsters, crabs, etc. Extended investigations, including the conditions affecting the growth and food value of oysters, their parasites and diseases, etc., have been carried on by the New Jersey Experiment Stations. These investigations have shown that oysters rapidly deteriorate when removed from the water, through the fermentative action of bacteria; and that oysters in spawn deteriorate more rapidly than at any other season at the same temperature. However, oysters which are ready to spawn are considered especially palatable if cooked soon after removal from the sea bed.

PREPARING FISH FOR MARKET.

Fish are sold either "round," i. e., whole, or dressed. Sometimes only the entrails are removed. Often, however, especially when dressed for cooking, the head, fins, and, less frequently, the bones, are removed. This entails a considerable loss in weight as well as of nutritive material.

It has been assumed that in dressing fish the following percentages are lost: Large-mouthed black bass, sea bass, cisco, kingfish, mullet, white perch, pickerel, pike, tomcod, weakfish, and whitefish, each, 17½ per cent; small-mouthed black bass, eel, Spanish mackerel, porgy, and turbot, each, 13½ per cent; butter-fish, 12½ per cent; shad, 11 per cent; and brook trout, 16½ per cent. More recent figures for loss in weight in dressing are as follows: Bullhead, 50 per cent; buffalo-fish and lake sturgeon, 40 per cent; carp and sucker, 35 per cent; fresh-water sheepshead, 23 per cent; grass pike, black bass, white bass, yellow perch, and salmon, 15 per cent; and eels, 10 per cent.

Fresh-water and salt-water fish alike are offered for sale as taken from the water, and preserved in a number of ways. In some cases preservation is only to insure transportation to remote points in good condition. Low temperature is the means most commonly employed for this purpose. By taking advantage of the recent improvements in apparatus and methods of chilling and freezing, fish may be shipped long distances and kept a long time in good condition. Some of the dangers from eating fish which is not in good condition are pointed out on page 29.

Large quantities of fish are dried, salted, and smoked, the processes being employed alone or in combination. These methods insure preservation, but at the same time modify the flavor. Several fish products are also prepared by one or more of these processes. Caviare, which may be cited as an example, is usually prepared from sturgeon roe by salting. The methods of salting and packing vary somewhat and give rise to a number of varieties. Although formerly prepared almost exclusively in Russia, caviare is now made to a large extent in the United States.

When fish are salted and cured, there is a considerable loss in weight due to removal of the entrails, drying, etc. Codfish lose 60 per cent in preparation for market. If the market-dried fish is boned, there is a further loss of 20 per cent. The loss in weight of pollock from the round to the market-dried fish is 60 per cent; haddock, 62 per cent; hake, 56 per cent; and cusk, 51 per cent.

The canning industry has been enormously developed in recent years and thousands of pounds of fish, oysters, lobsters, etc., are annually preserved in this way. In canning, the fish or other material is heated (the air being sometimes exhausted also) to destroy micro-organisms, and sealed to prevent access of air which would introduce micro-organisms as well as oxygen. Thus the canned contents are preserved from oxidation and decomposition. The processes of canning have been much improved, so that the original flavor is largely retained, while the goods may be kept for an indefinite period. Fish, as well as meat, is usually canned in its own juice or cooked in some form. Sardines and some other fishes are commonly preserved by canning in oil.

Various kinds of fish extract, clam juice, etc., are offered for sale. These are similar in form to meat extract. There are also a number of fish pastes and similar products—anchovy paste, for instance—which are used as relishes or condiments.

Preservatives such as salicylate of soda are employed to some extent in fish and especially oysters for shipping. The extended use of such materials is not desirable since some of them are justly regarded as harmful.

Oysters and other shellfish are placed on the market alive in the shell or are removed from the shell and kept in good condition by chilling or other means. Oysters in the shell are usually transported in barrels or sacks. Shipment is made to far inland points in refrigerator cars and to Europe in the cold-storage chambers of vessels. Large quantities of shellfish are also canned. Oysters are often sold as they are taken from the salt water. However, the practice of "freshening," "fattening," or "floating" is very widespread—that is, oysters are placed in fresh or brackish water for a short period. They become plump in appearance and have a different flavor from those taken directly from salt water (see p. 16). As noted on page 29, care should be taken that the oysters are fattened in water which is not contaminated by sewage.

Lobsters, crabs, and other crustacea are usually sold alive. Sometimes they are boiled before they are placed on the market. Large quantities of lobsters, shrimps, and crabs are canned.

Turtle and terrapin are usually marketed alive. Turtle soup, however, is canned in large quantities. Frogs are marketed alive or dressed. The hind legs only are commonly eaten. Frogs may be eaten in all seasons, but are in the best condition in the fall or winter.

NUTRITIVE VALUE OF FISH.

COMPOSITION OF FISH.

Fish contain the same kind of nutrients as other food materials. In general it may be said that food (fish, meat, cereals, vegetables, etc.) serves a twofold purpose: It supplies the body with material for building and repairing its tissues and fluids, and serves as fuel for maintaining body temperature and for supplying the energy necessary for muscular work.

The body is like a machine, with food for its fuel. The body differs from a machine, however, in that the fuel, i. e., food, is used to build it as well as supply it with energy. Further, if the body is supplied with more food than is needed, the excess can be stored as reserve material, usually in the form of fat. In the furnace fuel is burned quickly, yielding heat and certain chemical products—carbon dioxid, water vapor, and nitrogen. In the body the combustion takes place much more slowly, but in general the final products are the same. The combustion of nitrogen is, however, not so complete as in a furnace. Due allowance is made for this fact in calculations involving the question of the energy which food will furnish.

Food consists of an edible portion and refuse, i. e., bones of fish and meat, shells of oysters, bran of wheat, etc. Although foods are so different in appearance, chemical analysis shows that they are all made up of a comparatively small number of chemical compounds. These are water and the so-called nutrients, protein or nitrogenous materials, fat, carbohydrates, and ash, or mineral matter. Familiar examples of protein are lean of meat and fish, white of egg, casein of milk (and cheese), and gluten of wheat. Fat is found in fat meats, fish, lard, fat of milk (butter), and oils, such as olive oil. Starches, sugars, and woody fiber or cellulose form the bulk of the carbohydrates. Certain carbohydrates are found in meat and fish, although the amount is not large. The protein, fats, and carbohydrates are all organic substances—that is, they can be burned with the formation of various gases, chiefly carbon dioxid and water, leaving no solid residue. The mineral matters will not burn and are left behind when organic matter is ignited. By analysis the nutrients have been found to be made up of a comparatively small number of chemical elements in varying combinations. These are nitrogen, carbon, oxygen, hydrogen, phosphorus, sulphur, calcium, magnesium, sodium, potassium, silicon, chlorin, fluorin, and iron. Doubtless no single nutrient contains all these elements. The body tissues and fluids contain nitrogen; and hence protein, which alone supplies nitrogen to the body, is a necessary factor in food. All the nutrients except mineral matter contain carbon, oxygen, and hydrogen, and can supply them to the body. Protein, fat, and carbohydrates are all sources of energy.

The value of a food for building and repairing the body is shown by its chemical composition—that is, by the amount of the different nutrients which it contains. Some other means are necessary to show its value as a source of energy. It is known that all energy may be measured in terms of heat. In order to have some measure for expressing the amount of heat, the calorie is taken as a unit. Roughly speaking, this is the amount of heat required to raise the temperature of 1 pound of water 4° F. One pound of sugar or starch would, if burned and all the heat utilized, raise 1,860 pounds of water 4 degrees in temperature; or it would raise 5 gallons of water from the freezing point to the boiling point, but would not cause it to boil.

The number of calories which different foods will supply may be determined by burning them in an apparatus called a calorimeter, or by taking the sum of the calories which it is calculated the protein, fat, and carbohydrates making up the food would furnish. It has been found by experiment that the fuel value of a pound of protein as ordinarily burned in the body is 1,860 calories; the fuel value of a pound of carbohydrates is the same; while that of a pound of fat is 2¼ times as great.

The value of a food is usually judged by several different standards. Thus it must be digestible and palatable, furnish the nutrients needed by the system in proper amounts, and be reasonably cheap.

The relative nutritive value of any food is shown by comparing its composition with other foods. Table 1 shows the composition of a number of food fishes, fresh and preserved in a variety of ways; oysters, clams, and other mollusks; lobsters, shrimps, crawfish, and crabs; turtle and terrapin, and frogs' legs. For purposes of comparison the analyses of a number of kinds of meat, vegetables, and other common food materials, are included.

In several cases the analysis of fish, whole and dressed, is given. Usually the composition of the dressed fish was computed from that of whole fish with the aid of the figures for loss of weight in dressing for market, mentioned on page 9.

TABLE 1.—*Composition of fish, mollusks, crustaceans, etc.*

Kind of food material.	Refuse (bone, skin, etc.).	Salt.	Water.	Protein.	Fat.	Carbohydrates.	Mineral matter.	Total nutrients.	Fuel value per pound.
Fresh fish.	*Per ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*Calories.*
Alewife, whole	49.5	......	37.5	9.7	2.5	......	0.8	13	285
Bass, large-mouthed black, dressed	46.7	......	41.9	10.3	.5	......	.6	11.4	215
Bass, large-mouthed black, whole	56	......	34.6	8.5	.4	......	.5	9.4	175
Bass, small-mouthed black, dressed	46.4	......	40.1	11.5	1.3	......	.7	13.5	270
Bass, small-mouthed black, whole	53.6	......	34.7	10	1.1	......	.6	11.7	230
Bass, sea, dressed	46.8	......	42.2	10.1	.2	......	.7	11	195
Bass, sea, whole	56.1	......	34.8	8.3	.2	......	.6	9.1	160
Bass, striped, dressed	51.2	......	37.4	8.7	2.2	......	.5	11.4	255
Blackfish, dressed	55.7	......	35	8.3	.5	......	.5	9.3	175
Bluefish, dressed	48.6	......	40.3	9.8	.6	......	.7	11.1	205
Butterfish, dressed	34.6	......	45.8	11.7	7.2	......	.7	19.6	520
Butterfish, whole	42.8	......	40.1	10.2	6.3	......	.6	17.1	435
Carp (European analysis)	37.1	......	48.4	12.9	.7	......	.9	14.5	270
Cod, dressed	29.9	......	58.5	10.6	.2	......	.8	11.6	205
Cod, steaks	9.2	......	72.4	16.9	.5	......	1	18.4	835
Cusk, dressed	40.3	......	49	10.1	.1	......	.5	10.7	190
Eel, salt-water, dressed	20.2	......	57.2	14.6	7.2	......	.8	22.6	575
Flounder, common, dressed	57	......	35.8	6.3	.3	......	.6	7.2	130
Flounder, winter, dressed	56.2	......	37	6.1	.2	......	.5	6.8	120
Hake, dressed	52.5	......	39.5	7.2	.3	......	.5	8	145
Haddock, dressed	51	......	40	8.2	.2	......	.6	9	160
Halibut, dressed	17.7	......	61.9	15.1	4.4	......	.9	20.4	465
Herring, whole	46	......	37.3	10	5.9	......	.8	16.7	435
Mackerel, dressed	40.7	......	43.7	11.4	3.5	......	.7	15.6	360
Mackerel, Spanish, dressed	24.4	......	51.4	15.8	7.2	......	1.2	24.2	595
Mackerel, Spanish, whole	34.6	......	44.5	13.7	6.2	......	1	20.9	515
Mullet, dressed	49	......	38.2	9.8	2.4	......	.6	12.8	285
Mullet, whole	57.9	......	31.5	8.1	2	......	.5	10.6	235
Perch, white, dressed	54.6	......	34.4	8.7	1.8	......	.5	11	235
Perch, white, whole	62.5	......	28.4	7.2	1.5	......	.4	9.1	195
Perch, yellow, dressed	35.1	......	50.7	12.6	.7	......	.9	14.2	265
Pickerel, dressed	35.9	......	51.1	11.9	.2	......	.9	13	230
Pickerel, whole	47.1	......	42.2	9.8	.2	......	.7	10.7	190
Pike, dressed	30.5	......	55.4	13	.4	......	.7	14.1	260
Pike, whole	42.7	......	45.7	10.7	.3	......	.6	11.6	210
Pollock, dressed	28.5	......	54.3	15.5	.6	......	1.1	17.2	315
Pompano, dressed	45.5	......	39.5	10.2	4.3	......	.5	15	870
Porgy, dressed	53.7	......	34.6	8.6	2.4	......	.7	11.7	260
Porgy, whole	60	......	29.9	7.4	2.1	......	.6	10.1	225
Red grouper, dressed	55.9	......	35	8.4	.2	......	.5	9.1	165
Red snapper, dressed	48.9	......	40.3	9.6	.6	......	.6	10.8	205
Salmon, California (sections)	5.2	......	60.3	16.5	17	......	1	34.5	1,025
Salmon, Maine, dressed	23.8	......	51.2	14.6	9.5	......	.9	25	675
Shad, dressed	43.9	......	39.6	10.3	5.4	......	.8	16.5	420
Shad, whole	50.1	......	35.2	9.2	4.8	......	.7	14.7	375
Shad, roe	......	......	71.2	23.4	3.8	......	1.6	28.8	595
Smelt, whole	41.9	......	46.1	10	1	......	1	12	230
Sturgeon, dressed	14.4	......	67.4	15.4	1.6	......	1.2	18.2	355
Tomcod, dressed	51.4	......	39.6	8.2	.3	......	.5	9	165
Tomcod, whole	59.9	......	32.7	6.8	.2	......	.4	7.4	135
Trout, brook, dressed	37.9	......	48.4	11.7	1.3	......	.7	13.7	275
Trout, brook, whole	48.1	......	40.4	9.8	1.1	......	.6	11.5	230
Trout, lake, dressed	35.2	......	45	12.4	6.6	......	.8	19.8	510
Turbot, dressed	39.5	......	43.1	7.9	8.7	......	.8	17.4	515
Turbot, whole	47.7	......	37.8	6.8	7.5	......	.7	15	440
Weakfish, dressed	41.7	......	46.1	10.2	1.3	......	.7	12.2	245
Weakfish, whole	51.9	......	38	8.4	1.1	......	.6	10.1	200

TABLE 1.—*Composition of fish, mollusks, crustaceans, etc.*—Continued.

Kind of food material.	Refuse (bone, skin, etc.).	Salt.	Water.	Protein.	Fat.	Carbohydrates.	Mineral matter.	Total nutrients.	Fuel value per pound.
Fresh fish—Continued.	*Per ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*Calories.*
Whitefish, dressed	43.6	......	39.4	12.5	3.6	......	0.9	17	385
Whitefish, whole	53.5	......	32.5	10.3	3	......	.7	14	320
General average of fresh fish as sold	42	......	44	10.5	2.5	......	1	14	300
Preserved fish.									
Mackerel, "No. 1," salted	33.3	7.1	28.1	14.7	15.1	......	1.7	31.5	910
Cod, salted and dried	24.9	17.2	40.3	16	.4	......	1.2	17.6	315
Cod, "boneless codfish," salted and dried	......	21.5	54.4	22.1	.3	......	1.7	24.1	425
Caviare	......	......	38.1	30	19.7	7.6	a4.6	61.9	1,530
Herring, salted, smoked, and dried	44.4	6.5	19.2	20.2	8.8	......	.9	29.9	45
Haddock, "finnan haddie," salted, smoked, and dried	32.2	1.4	49.2	16.1	.1	......	1	17.2	305
Halibut, salted, smoked, and dried	6.9	12.1	46	19.1	14	......	1.9	35	945
Sardines, canned	5	......	53.6	24	12.1	......	5.3	41.4	955
Salmon, canned	3.9	1	59.3	19.3	15.3	......	1.2	35.8	1,005
Mackerel, canned	......	1.9	68.2	19.9	8.7	......	1.3	29.9	735
Mackerel, salt, canned	19.7	8.3	34.8	13.8	21.3	......	2.1	37.2	1,155
Tunny (horse-mackerel), canned	......	......	72.7	21.5	4.1	......	1.7	27.3	575
Haddock, smoked, canned	......	5.6	68.7	21.8	2.3	......	1.6	25.7	505
Mollusks.									
Oysters, solids	......	......	88.3	6.1	1.4	3.3	.9	11.7	235
Oysters, in shell	82.3	......	15.4	1.1	.2	.6	.4	2.3	40
Oysters, canned	......	......	85.3	7.4	2.1	3.9	1.3	14.7	300
Scallops	......	......	80.3	14.7	.2	3.4	1.4	19.7	345
Long clams, in shell	43.6	......	48.4	4.8	.6	1.1	1.5	8	135
Long clams, canned	......	......	84.5	9	1.3	2.9	2.3	15.5	275
Round clams, removed from shell	......	......	80.8	10.6	1.1	5.2	2.3	19.2	340
Round clams, in shell	68.3	......	27.3	2.1	.1	1.3	.9	4.4	65
Round clams, canned	......	......	83	10.4	.8	3	2.8	17	285
Mussels	49.3	......	42.7	4.4	.5	2.1	1	8	140
General average of mollusks (exclusive of canned)	60.2	......	34	3.2	.4	1.3	.9	5.8	100
Crustaceans.									
Lobster, in shell	62.1	......	31.1	5.5	.7	......	.6	6.8	130
Lobster, canned	......	......	77.8	18.1	1.1	.6	2.4	22.2	395
Crawfish, in shell	87.7	......	10	2	.1	.1	.1	2.3	45
Crab, in shell	55.8	......	34.1	7.3	.9	.5	1.4	10.1	185
Crab, canned	......	......	80	15.8	1.5	.8	1.9	20	370
Shrimp, canned	......	......	70.8	25.4	1	.2	2.6	29.2	520
General average of crustaceans (exclusive of canned)	73.7	......	20.9	4.3	.4	.2	.5	5.4	100
Terrapin, turtle, etc.									
Terrapin, in shell	79	......	15.6	4.5	.7	......	.2	5.4	115
Green turtle, in shell	76	......	19.1	4.5	.1	......	.3	4.9	90
Average of turtle and terrapin	77.5	......	17.4	4.2	.7	......	.2	5.1	105
Frogs' legs	32	......	57	10.2	.1	......	.7	11	210
General average of fish, mollusks, crustaceans, etc	44	......	42.5	10	2.5	.1	.9	13.5	295
Other animal foods.									
Beef, side, medium fat	17.4	......	49.4	14.4	18.1	......	.7	33.2	1,030
Veal, side	22.6	......	55.2	15.1	6.3	......	.8	22.2	545
Mutton, side	19.3	......	43.3	12.7	24	......	.7	37.4	1,250
Average of beef, veal, and mutton	20	......	49.5	14.2	15.6	......	.7	30.5	920
Pork, side	11.2	......	26.1	7.5	54.8	......	.4	62.7	2,455
Chicken	26.6	......	47.2	14	11.5	......	.7	26.2	750
Turkey	22.7	......	42.4	15.7	18.4	......	.8	34.9	1,070
Milk	......	......	87	3.3	4	5	.7	13	325
Vegetable foods.									
Wheat flour	......	......	12.1	11.2	1.1	75.2	.4	87.9	1,655
Corn meal	......	......	12.2	9.3	2.4	75.1	1	87.8	1,670
Beans, dried	......	......	12.8	22.5	1.8	59.3	3.6	87.2	1,595
Potato	20	......	62.6	1.7	.1	14.8	.8	17.4	310
Cabbage	15	......	77.7	1.4	.2	4.8	.9	7.3	125
Corn, canned	......	......	75.8	2.8	1.2	19.3	.9	24.2	460
Salad greens	......	......	86.7	4.2	.6	6.3	2.2	13.3	220
Apples	25	......	62.9	.3	.4	11.2	.2	12.1	230
Bananas	35	......	48.1	.8	.5	15.1	.5	16.9	315
Strawberries	......	......	90.4	1	.7	7.3	.6	9.6	185

a Including salt.

The above list includes the more important food fishes, water invertebrates, etc. There are numbers of other fish which are eaten to a greater or less extent. In general it may be said their composition would be similar to that of the fishes included in the table. It is noticeable that many kinds of fish which are known to be wholesome are seldom eaten. Among others may be mentioned the whiting, or silver hake, and the sea robin. The latter are taken in enormous quantities in certain regions. This prejudice against certain fish is largely local; for instance, skates are eaten on the western coast of the United States, but until recently they were regarded as of no value in the East. A few years ago sturgeon and eel were not generally eaten. To-day sturgeon is much prized, and in regions where it was formerly worthless commands a high price.

In a number of cases cited in the table above more than one specimen was analyzed, although only the averages are given in the table. In such cases the samples showed more or less variation in total nutrients, but the variation was due more especially to the fats. Thus the fat in the flesh of seven specimens of shad ranged from 6.5 to 13.6 per cent; in fresh mackerel from 2.2 to 16.3 per cent, and in fresh halibut from 2.2 to 10.6 per cent. The protein and mineral matters remained practically the same in all these specimens where the wide fat variation was noticeable, an increase of fat being marked by a decrease of water.

It will be seen from the table that fish is essentially a nitrogenous food. In this it resembles meat. Neither fish nor meat is a source of carbohydrates.. Oysters contain some carbohydrates, but the foods which supply this group of nutrients most abundantly are the cereal grains.

In general, it may be said that fish, meat, eggs, milk, etc., also cereals and vegetable foods, all supply fat, the amount varying in the different materials. Fish usually contains less fat than is found in meat. There is, however, much difference in the fat content of the various kinds of fish. They may, indeed, be roughly divided into three classes: The first class would include those containing over 5 per cent fat; the second those containing between 2 and 5 per cent, and the third those containing less than 2 per cent. The first group would include such fish as salmon, shad, herring, Spanish mackerel, and butter-fish; the second, white fish, mackerel, mullet, halibut, and porgy; the third, smelt, black bass, bluefish, white perch, weakfish, brook trout, hake, flounder, yellow perch, pike, pickerel, sea bass, cod, and haddock.

The so-called nitrogenous extractives ("meat extract"), contained in small quantities in fish as in other animal foods, are doubtless useful in nutrition, although their function is not definitely known.

The place of fish in the diet, if judged by its composition, is the same as that of meat; that is, it is supplementary to cereals and other vegetables, the most of which, as wheat, rye, maize, rice, potatoes, etc., are deficient in protein, the chief nutrient in the flesh of fish.

Preserved fish, as a rule, show a small percentage of refuse, with the exception of a few kinds which are preserved whole. The percentage of actual nutrients is much larger than in the corresponding fresh fish, owing to the removal of a large part of the refuse and more or less water. The gain in nutrients is mostly represented by protein, which is the most valuable nutrient.

Canned fish, which is in effect cooked fish, compares favorably as regards composition with the fresh material. Generally speaking, the amount of refuse is small, since the portions commonly rejected in preparation for the table have been removed before canning.

Shellfish resemble meat and food fishes in general composition. They contain, however, a small amount of carbohydrates. Oysters are the most important of the shellfish, judging by the relative amount consumed. Speaking roughly, a quart of oysters contains on an average about the same quantity of actual nutritive substances as a quart of milk, or three-fourths of a pound of beef, or 2 pounds of fresh codfish, or a pound of bread. But while the weight of actual nutriment in the different quantities of food materials named is very nearly the same, the kind is widely different. That of the lean meat or codfish consists mostly of protein, the substances whose principal function is to make or repair blood, muscle, tendon, bone, brain, and other nitrogenous tissues. That of bread contains considerable protein, but a much larger proportion of starch, with a little fat and other compounds which serve the body as fuel and supply it with heat and muscular power. The nutritive substance of oysters contains considerable protein and fuel ingredients. Oysters come nearer to milk than almost any other common food material as regards both the amounts and the relative proportions of nutrients.

Apparently as the oyster grows older, at least up to a certain time, not only do the proportion of flesh and liquids increase more rapidly than the shells, but the proportion of nutrients in the edible portion increases also; that is to say, 100 pounds of young oysters in the shell appear to contain less of flesh and of liquids than 100 pounds of older ones, and when both have been shucked a pound of shell contents from the older oysters would contain more nutriment than a pound from the younger.

Considering the edible portion of the oyster, after it has been removed from the shell, the differences in different specimens are much greater than is commonly supposed. This is apparent when a comparison is made of either the flesh (meat) or liquids (liquor) of different specimens, or the whole edible portion, the meat (solids) and liquor together. The percentage of water in the edible portion of different specimens of oysters which were analyzed in experiments conducted for the U. S. Fish Commission varied from about 83.4 to 91.4 per cent, and averaged 87.3 per cent. This makes the amounts of "water-free substance," i. e., actually nutritive ingredients, vary from 16.6 to 8.6 and average

12.7 per cent of the whole weight of the edible portion (shell contents) of the animals. In other words, the nutritive material in a quart (about 2 pounds) of shell contents (solids) varied from 2¾ to 5⅓ ounces.

With oysters, long clams, and round clams in the shell there is naturally a large percentage of waste, as the shell is a large portion of the total weight. The average of 34 specimens of oysters in the shell, for instance, shows only 2.3 per cent of actual nutrients. Clams and mussels show a somewhat higher percentage.

Where these various shellfish are purchased as "solids"—that is, removed from the shell—a comparatively high price is usually paid. Where they are purchased in the shell, there is a very large ~~percentage~~ of waste. The conclusion is therefore warranted that, from a pecuniary standpoint, they are not the most economical of foods for the consumer. On the other hand, they have a useful place in the diet in helping to supply the variety which is apparently needed to insure the best workings of the digestive system. Often flavor has a value which can not be estimated in dollars and cents.

As already explained, it is a common practice of oyster dealers, instead of selling the oysters in the condition in which they are taken from the beds in salt water, to place them for a time—forty-eight hours, more or less—in fresh or brackish water, in order, as the oystermen say, to "fatten" them, the operation being also called "floating" or "laying out." By this process the oyster acquires plumpness and rotundity, and its bulk and weight are so increased as materially to increase its selling value. The belief is common among oystermen that this "fattening" is due to actual gain of flesh and fat and that the nutritive value of the oyster is increased by the process. They find that the oysters "fatten" much more quickly in fresh than in brackish water. Warmth is so favorable to the process, that it is said to be sometimes found profitable to warm artificially the water in which the oysters are floated. Although oysters are generally floated in the shell, the same effect is commonly obtained by adding fresh water to the oysters after they have been taken out of the shell. Oysters lose much of their salty flavor in "floating," and it is a common experience of oystermen that if the "fattened" oysters are left too long on the floats they become "lean" again. It does not seem probable that the oysters would secure food enough to make appreciable gain in weight in the short time in which they remain in the fresh or brackish water.

It is known that when a solution of salts is separated by a suitable membrane from water containing a lesser quantity of salts in solution that the passage of salts immediately begins from the concentrated to the dilute solution. This is practically the condition which exists when the oyster is transferred from salt to fresh or brackish water. The fleshy portions of the body which are inclosed in a membrane contain salts in solution. As long as the oyster stays in salt water the solution of salts within its body would naturally be in equilibrium with the water outside. When the oyster is brought into fresh or brackish water—i. e., into a more dilute solution—it might be expected that the salts in the more concentrated solution within the body would pass out and a larger amount of fresh water enter and produce such a distension as actually takes place during floating. Careful experiments have shown that this supposition is entirely correct—that is, the oysters actually gain in weight. This is due largely to the fact that they lose mineral matter and gain a considerable amount of water. At the same time there is a slight loss of nutrients. When in their natural condition oysters contain from one-eighth to one-fifth more nutritive material than when fattened. In the opinion of very many consumers the improvement in appearance and flavor due to the removal of the salts more than compensates for the loss in nutritive value. It seems also to be a matter of common opinion that oysters keep better when part of the salts has been removed by "floating." However, the experiments of the New Jersey Stations have shown that freshened oysters will not remain alive as long as those taken directly from salt water. Freshening increases very rapidly the rate of weakening and decay (the life period being reduced one half).

Frequently oysters become more or less green in color. There is a widespread opinion that "greening" is injurious. The color has been attributed to disease, to parasites, and to the presence of copper. It is in reality due to the fact that the oysters have fed on green plants of very simple structure which are sometimes found in abundance in brackish or salt water. The green coloring matter of the plants is soluble in the oyster juices and colors the tissues. The opinion of those who have investigated the matter carefully is that the green color is harmless. In Europe green oysters are more highly prized than others. The green color may be removed by placing the oysters for a time in water where the green plants are not abundant.

Lobsters, crabs, shrimps, and crawfish are shown by analysis to contain a fairly large percentage of nutrients. This is more noticeable when the composition of the flesh alone is considered. Lobsters and similar foods are prized for their delicate flavor. Except in certain regions where they are very abundant and the cost correspondingly low they must be regarded as delicacies rather than as staple articles of diet. This is, however, a condition entirely apart from their composition. Judged by this alone, they are valuable foods, and may profitably be employed to give variety to the diet.

Although the total amount of turtle and terrapin used in the United States is considerable, the quantity is small as compared with the consumption of such foods as fish proper and oysters. As shown by their composition, turtle and terrapin are nutritious foods, although, under existing conditions, they are expensive delicacies rather than staple and economical articles of diet.

The total amount of frogs consumed per year for food is considerable. As shown by analysis, frogs' legs contain a considerable amount of protein. Only the hind legs are commonly eaten. The meat on other portions of the body is edible, although the amount is small, and is eaten in some localities. The prejudice which formerly existed against frogs' legs as a food was doubtless based on their appearance or some similar reason, as they are known to be wholesome.

COST OF PROTEIN AND ENERGY IN FISH AND OTHER FOOD MATERIALS.

As previously stated, the two functions of food are to furnish protein for building and repairing the body and to supply energy for heat and muscular work. Although fish and meats in general may be regarded as sources of protein, they nevertheless furnish considerable energy. Indeed, those containing an abundance of fat supply a large amount of energy—that is, have a high fuel value. If a food contains little protein or energy and is high in price, it is evident that it is really an expensive food. On the other hand, a food may be high in price but in reality be cheap, since it furnishes a large amount of protein or energy or both. Foods which supply an abundance of protein or energy or both at a reasonable price are evidently of the greatest importance from an economical standpoint.

In Table 2 is shown how much a pound of protein, or 1,000 calories of energy, would cost when supplied by a number of kinds of fish and other foods at certain prices.

Table 2.—*Comparative costs of protein and energy as furnished by a number of food materials at certain prices.*

Kind of food material.	Price per pound.	Cost of protein per pound.	Cost of energy per 1,000 calories.
	Cents.		
Codfish	10	$0.94	$0.49
Codfish steaks	12	.71	.36
Bluefish	12	1.22	.59
Halibut	18	1.18	.38
Cod, salt	7	.44	.22
Mackerel, salt	10	.68	.11
Salmon, canned	12	.55	.13
Oysters, "solids" (30 cents per quart)	15	2.50	.65
Oysters, "solids" (60 cents per quart)	30	5.00	1.30
Beef, sirloin	25	1.63	.26
Do	20	1.23	.21
Beef, round	14	.77	.16
Beef, stew meat	5	.36	.07
Beef, dried "chipped"	25	.97	.32
Mutton chops (loin)	20	1.54	.14
Mutton leg	22	1.48	.25
Pork roast (loin)	12	.85	.09
Pork, smoked ham	22	1.65	.13
Milk (7 cents per quart)	3½	1.06	.11
Milk (6 cents per quart)	3	.91	.09
Lobster	18	3.05	1.24
Wheat flour	3	.27	.02
Corn meal	2	.22	.01
Potatoes (90 cents per bushel)	1½	.88	.05
Potatoes (45 cents per bushel)	¾	.44	.02
Cabbage	2½	1.79	.20
Corn, canned	10	3.57	.22
Apples	1½	5.00	.07
Bananas	7	8.75	.22
Strawberries	7	7.00	.38

In the table the prices per pound have been selected from the best data available. It is of course impossible to set any one price which shall represent the cost of these materials per pound in all sections of the country and at all times of the year. It is probable that the prices given represent more nearly those found in the eastern part of the country than in the southern, central, and western sections, where most of the food materials are usually somewhat cheaper.

It is to be noted that the cost of 1 pound of protein and 1,000 calories of energy have no direct relation to each other. A pound of protein would be sufficient for a workingman nearly four days, while 1,000 calories of energy would be less than one-third the amount required per day. By dividing the cost of 1 pound of protein by 4 and multiplying the cost of 1,000 calories of energy by 3.5 results are obtained which show the relative cost of the protein and energy sufficient for one day as furnished by the different food materials. Thus it would take 25 cents' worth of salt mackerel at 10 cents a pound to furnish one day's supply of protein, while the corresponding energy would require 38 cents' worth. Seven cents' worth of flour would furnish the protein and 5 cents' worth the energy required for one day. It is of course understood that no one food material could furnish the nutrients in the proper proportions for adults under ordinary conditions of health and activity. The values expressed in the table simply show the relative value from a pecuniary standpoint of the different foods as a source of protein on the one hand and of energy on the other.

It will be seen from the above table that at 25 cents a pound it would take $1.53 worth of sirloin steak to furnish a pound of protein, while the same amount could be obtained in 77 cents' worth of beef round at 14 cents a pound, 71 cents' worth of cod steak at 12 cents a pound, 44 cents' worth of salt cod at 7 cents a pound, or 27 cents' worth of wheat flour at 3 cents a pound. In like manner the cost of 1,000 calories of energy would vary in these same food materials from 36 cents, as furnished by the cod steaks, to 2 cents as furnished by the flour.

It is evident that at the prices given the fruits are the most expensive sources of protein, mollusks and crustaceans next, and the cheaper meats and fish, with the cereals, the least expensive. As regards energy, on the other hand, mollusks and crustaceans are by far the most expensive sources, followed by fish and many kinds of meat, while the cereals are the most economical.

DIGESTIBILITY OF FISH.

The term digestibility, as commonly employed, has several significations. To many persons it conveys the idea that a particular food agrees with the user. It is also very commonly understood to mean the ease or rapidity of digestion. One food is often said to be preferable to another because it is more digestible—i. e., is digested in less time. A third meaning, and one which is usually understood in scientific treatises on such subjects, refers to the completeness of digestion.

For instance, two foods may have the same composition, but, owing to differences in mechanical condition or some other factor, one may be much more completely digestible than the other—that is, give up more material to the body in its passage through the intestinal tract.

The agreement or disagreement of a particular food with any person is largely a matter of individual peculiarity. When foods habitually disagree with a person, and there is reason to believe that there is pronounced indigestion, the advice of a competent physician is needed, since the nourishment of an abnormal or diseased body is a matter properly included under the practice of medicine.

In so far as ease or rapidity of digestion implies a saving of energy to the body, it is a matter of importance. However, little is known concerning relative rapidity of digestion within the body. Most of the current statements which refer to this are apparently based on experiments carried on outside the body by methods of artificial digestion. Such experiments imitate as closely as possible the conditions in the body, but it is not at all certain that they are exactly the same. The application of the results of such experiments is properly the province of trained investigators, who, it is worthy of note, are much more guarded in their statements than less well-informed persons.

Numbers of artificial-digestion experiments have been made with fish. These indicate that fish is less quickly digested than beef, being about equal to lamb in this respect. However, as compared with other foods, the difference in digestibility of fish and meat is not very great. Before sweeping deductions are made the thoroughness with which fish is digested should also be taken into account.

A number of experiments have been made with man to learn how thoroughly fish is digested and to compare it in this respect with other foods. In these experiments the food and feces were analyzed. Deducting the nutritive material excreted in the feces from the total amount consumed in the food showed how much was retained by the body. It was found that fish and lean beef were about equally digestible. In each case about 95 per cent of the total dry matter, 97 per cent of the protein, and over 90 per cent of the fat were retained by the body. Other experiments of the same character indicate that salt fish is less thoroughly digested than fresh fish.

A number of similar experiments have been made on the digestibility of milk, eggs, bread, potatoes, and other animal and vegetable foods. From them some general deductions have been drawn. Leaner meats are probably more easily digested than those containing more fat, and the leaner kinds of fish, such as cod, haddock, perch, pike, bluefish, etc., are more easily and completely digested than the fatter kinds, as salmon, shad, and mackerel. Generally speaking, it has been found that the protein of vegetable foods is less digestible than that of animal foods. For instance, one-fourth or more of the protein of potatoes and beans may escape digestion and thus be useless for nourishment. This is perhaps entirely due to the mechanical condition in which the protein occurs in vegetable foods; that is, it is often inclosed in cells which have hard walls and are not acted upon by the digestive juices. It is ordinarily assumed that the small amount of carbohydrates in meat and fish is entirely digested. Carbohydrates other than fiber, which make up the larger part of the vegetable foods, are very digestible. The fat in both animal and vegetable foods differs in digestibility under varying conditions. No marked difference in the digestibility of the fat in the two classes of food can be pointed out.

Persons differ in respect to the action of foods in the digestive apparatus; and fish, like other food materials, is subject to these influences of personal peculiarity.

The nutritive value of shellfish, as of other fish, depends to a considerable extent upon their digestibility; but so little is known upon this point that but little can be said with certainty here. Perhaps the most that can be said is that while there are people with whom such foods do not always agree, yet oysters belong to the more easily digestible class of foods. So far as can be learned no experiments have been made which show how thoroughly crabs, clams, and other crustacea, turtle and terrapin, and frogs' legs, are digested.

PLACE OF FISH IN THE DIET.

The chief uses of fish as food are (1) to furnish an economical source of nitrogenous nutrients and (2) to supply the demand for variety in the diet, which increases with the advance of civilization.

Inspection of a considerable number of dietary studies of families of farmers, mechanics, professional men, and others, carried on in different regions of the United States, shows that from one-half to two-thirds of the protein of the food is obtained from animal sources—i. e., meats, milk, eggs, and fish. In most cases fish furnish less than 5 per cent of the animal protein, showing to what a limited extent this food is used in the average household. It is not improbable that in communities where fisheries constitute the principal industry much larger quantities are consumed. It has been found that the laborers employed in the fisheries in Russia consume from 26 to 62 ounces of fish daily. This, with some bread, millet meal, and tea, constitutes the diet throughout the fishing season. These quantities are unusually large, but no bad effects are mentioned as following the diet.

There is a widespread notion that fish contains large proportions of phosphorus, and on that account is particularly valuable as brain food. The percentages of phosphorus in specimens thus far analyzed are not larger than are found in the flesh of other animals used for food. But, even if the flesh be richer in phosphorus, there is no experimental evidence to warrant the assumption that fish is more valuable than meats or other food material for the nourishment of the brain.

The opinion of eminent physiologists is that phosphorus is no more essential to the brain than nitrogen, potassium, or any other element which occurs in its tissues. The value commonly attributed to the phosphorus is based on a popular misconception of statements by one of the early writers on such topics. In discussing the belief that "fish contains certain elements which are adapted in a special manner to renovate the brain and so to support mental labor" a prominent physiologist says, "There is no foundation whatever for this view."

It is well understood that persons in varying conditions of life and occupation require different kinds and quantities of food. For the laboring man doing heavy work the diet must contain a comparatively large amount of the fuel ingredients and enough of the flesh-forming substances to make good the wear and tear of the body. These materials are all present in the flesh of animals, but not in the requisite proportions. Fish and the leaner kinds of meat are deficient in materials which yield heat and muscular power. When, however, fish and meat are supplemented by bread, potatoes, etc., a diet is provided which will supply all the demands of the body. Where fish can be obtained at low cost it may advantageously furnish a considerable portion of the protein required, and under most conditions its use may be profitably extended solely on the plea of variety.

It should be stated that most physiologists regard fish as a particularly desirable food for persons of sedentary habits. While, so far as can be learned, such statements do not depend upon experimental evidence, they are thought to embody the result of experience.

PREPARING FISH FOR THE TABLE.

Fish is prepared for the table in a variety of ways, which are described in detail in books devoted to cookery. A few words, however, may not be inappropriate on the general methods of cooking and possible loss of nutrients involved.

Fish is commonly boiled, steamed, broiled, fried, or baked, or may be combined with other materials in some made dish. When boiled, it is stated that the loss in weight ranges from 5 to 30 per cent. One experimenter gives 26 per cent as the average. This loss is largely made up of water—that is, the cooked fish is much less moist than the raw. Little fat or protein is lost. So far as known, experiments have not been made which show the losses by other methods of cooking. It is, however, probable that there would be usually a very considerable loss of water.

In most cases fat or carbohydrates in the form of butter, flour, or other material are added to fish when cooked, and thus the deficiency in fuel ingredients is made good. Boiled or steamed fish is often accompanied by a rich sauce, made from butter, eggs, etc. Fried fish is cooked in fat, and baked fish is often filled with force meat, and may also be accompanied by a sauce. The force meat being made of bread, butter, etc., contains fat and carbohydrates. In made dishes—chowders, fish pies, salads, etc.—fat and carbohydrates (butter, flour, vegetables, etc.), are combined with fish, the kind and amount varying in the individual cases. Furthermore, in the ordinary household, fish or meat is supplemented by such foods as bread, butter, potatoes, green vegetables, and fruit. That is, by adding materials in cooking and by serving others with the cooked product the protein of the fish is supplemented by the necessary fat and carbohydrates.

DAILY MENUS CONTAINING FISH.

By taking into account the chemical composition of a mixed diet and comparing it with accepted dietary standards it may be seen whether the diet is actually suited to the requirements of the body; that is, whether it supplies sufficient protein and energy and whether it suppplies them in the right proportions.

A number of sample menus are given on pp. 24–27, which show that the desired amounts of protein and energy may be readily supplied by a diet containing a considerable amount of fish. These menus (which are based in part on dietary studies and other food investigations of this Department covering a wide range and extending over several years) are not intended as formulas for any family to follow, but simply as illustrations of the way in which menus containing the proper proportions of nutrients may be made up. The ingenuity of the housewife and her knowledge of the tastes of the family will suggest the special dishes and combinations suited to her needs. It is not assumed that any housewife will find it convenient to follow exactly the proportions suggested in the menus. The purpose is to show her about what amounts and proportions of food materials would give the required nutrients.

With reference to the following menus several points should be borne in mind. The amounts given represent about what would be called for in a family whose demand for food would be equivalent to four full-grown men at ordinary manual labor, such as machinists, carpenters, mill workers, farmers, truckmen, etc., according to the usually accepted standards. It is ordinarily assumed that an average man in health performing a moderate amount of muscular work requires per day about 0.28 pound protein and 3,500 calories of energy, the latter being supplied in small part by protein, but mostly by fat and carbohydrates. Men in professional life, performing less muscular work, require smaller amounts. Accepted dietary standards for such men call for 0.22 to 0.25 pound protein and from 2,700 to 3,000 calories of energy in the daily food. The amount of mineral matter required is not stated, since there is little accurate information available on this point. A diet made up of ordinary foods and supplying the necessary amounts of protein and energy would undoubtedly supply an abundance of mineral matter.

It has been found that women and children consume somewhat less food than men. The assumption is usually made that, provided a woman is engaged in some moderately active occupation she requires about eight-tenths as much food as a man.

In calculating the results of dietary studies (which may be most conveniently expressed in amounts for one man for one day), it is further assumed that a boy 14 to 16 years old requires about eight-tenths as much food as a man at moderate muscular labor; a girl 14 to 16 years old, about seven-tenths; a child 10 to 13, about six-tenths; one 6 to 9 years old, about five-tenths; one 3 to 5, about four-tenths, and an infant under 3 years, about three-tenths.

As previously stated, the quantities in the sample menus are for four men at moderate muscular work or an equivalent number of men, women, and children. A family might, for example, consist of a mechanic and wife, with four children, two girls of 12 and 6 and two boys of 10 and 8 years, respectively. Here it would be assumed that the man would be engaged at moderately hard manual work. According to the above factors, this family would be equal in food consumption to 4 men at moderate muscular exercise (1.0+0.8+0.6+0.6+0.5+0.5=4). In the same way a day laborer's family consisting of a father and mother with three children under 7 years of age would be equivalent to 3 men with moderate muscular exercise (1.0+0.8+0.5+0.4+03=3), and would require three-fourths the quantities indicated in the following menus:

MENU I.—*For family equivalent to four men at moderate muscular work.*

Food material.	Weight.		Protein.	Fuel value.
Breakfast.	*Lbs.*	*Oz.*	*Pounds.*	*Calories.*
Oranges	2	0	0.012	300
Rolled oats:				
Oats		4	.042	462
Milk		6	.012	120
Sugar		2		235
Omelet (8 eggs)	1	0	.131	630
Butter for frying		1		220
Johnnycake *a*	1	4	.106	1,438
Butter		3	.001	660
Coffee			.008	250
Total			.312	4,315
Dinner.				
Boiled cod, fresh	2	0	.340	670
Hollandaise sauce:				
Butter		4	.002	880
Yolks of 2 eggs		1½	.012	136
Lemon juice, etc				
Potatoes	2	0	.034	620
Spinach	1	4	.027	138
Butter		1		220
Bread pudding:				
Bread		4	.024	301
Milk	1	8	.049	487
1 egg		2	.016	81
Sugar		3		350
Butter		½		105
Bread		12	.071	910
Butter		4	.002	880
Total			.577	5,778

a Composition of cooked material.

Menu I.—*For family equivalent to four men at moderate muscular work*—Continued.

Food material.	Weight.		Protein.	Fuel value.
Supper.				
Scalloped oysters:	*Lbs.*	*Oz.*	*Pounds.*	*Calories.*
Oysters	2	0	0.120	460
Crackers		4	.025	498
Butter		2	.001	440
Milk		4	.008	81
French fried potatoes	1	0	.017	310
Lard (taken up in frying)		2	....	530
Bread		8	.047	610
Butter		2	.001	440
Sliced bananas	1	0	.006	310
Sugar		4	....	465
Tea	....		.008	250
Total	....		.233	4,394
Total per day	....		1.122	14,487
Total for one man	....		.28	3,622

Menu II.—*For family equivalent to four men at moderate muscular work.*

Food material.	Weight.		Protein.	Fuel value.
Breakfast.				
Creamed codfish:	*Lbs.*	*Oz.*	*Pounds.*	*Calories.*
Salt codfish		8	0.111	253
Milk	1	0	.033	325
Butter		1	....	220
Flour		1	.007	103
Baked potatoes a	2	0	.034	620
Bread		12	.071	910
Butter		4	.002	880
Coffee	....		.008	250
Total	....		.266	3,561
Dinner.				
Fish soup:				
Halibut	1	0	.153	470
Milk	2	0	.066	650
Butter		1	....	220
Flour		1	.007	103
(Onion, salt, pepper)	....		....	....
Roast lamb, loin b	1	8	.195	2,167
Green peas c	1	12	.039	350
Butter		1¾	.001	380
Mashed potatoes a	1	8	.025	465
Bread		6	.036	455
Butter		1	....	220
Apple pie	1	0	.031	455
Total	....		.553	5,935
Supper.				
Lobster salad:				
Lobster meat	1	0	.164	390
Yolks of 3 eggs		2	.018	204
Butter or oil		3	.002	660
Milk		8	.017	162
Sugar		1	....	118
(Vinegar, salt, pepper, mustard)	....		....	....
Biscuit	1	0	.084	1,430
Butter		4	.002	880
Tea	....		.008	250
Total	....		.350	4,094
Total per day	....		1.179	13,590
Total for one man	....		.29	3,398

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a Composition of cooked material.
b A larger roast would ordinarily be cooked. The amount given would be sufficient for one meal.
c Weight with pods.

MENU III.—*For family equivalent to four men at moderate muscular work.*

Food material.	Weight.		Protein.	Fuel value.
Breakfast.	*Lbs.*	*Oz.*	*Pounds.*	*Calories.*
Bananas or grapes	1	0	0.009	325
Rolled oats:				
Oats		4	.042	465
Milk		6	.012	120
Sugar		2	....	235
Creamed dried beef:				
Dried beef		12	.194	585
Milk		8	.017	163
Butter		1	....	220
French fried potatoes	1	0	.017	310
Lard (taken up in frying)		2	....	530
Bread		12	.071	910
Butter		3	.001	660
Coffee	....		.008	250
Total	....		.317	4,773
Dinner.				
Halibut steak	2	0	.306	940
Mashed potatoes	2	0	.034	620
Tomatoes (or half the amount of parsnips)	2	0	.018	210
Bread		12	.071	910
Butter		4	.002	880
Caramel custard:				
Milk	1	0	.033	325
2 eggs		4	.033	158
Sugar		4	....	470
Total	....		.497	4,513
Supper.				
Salmon croquettes:				
Canned salmon		8	.109	458
Mashed potatoes *a*	1	0	.017	310
Butter		½	....	110
1 egg		2	.016	79
Lard (taken up in frying)		1	....	265
Preserves	1	0	.008	1,150
Muffins		12	.089	982
Butter		4	.002	880
Tea	....		.008	250
Total	....		.249	4,484
Total per day	....		1.117	13,770
Total for one man	....		.279	3,443

a Composition of cooked material.

MENU IV.—*For family equivalent to four men at moderate muscular work.*

Food material.	Weight.		Protein.	Fuel value.
Breakfast.				
Oatmeal:	*Lbs.*	*Oz.*	*Pounds.*	*Calories.*
Oatmeal		4	0.042	465
Milk		6	.012	120
Sugar		2	....	235
Broiled salt mackerel	1	8	.209	1,733
Boiled potatoes	1	0	.017	310
Hot rolls		12	.077	1,148
Butter		3	.001	660
Coffee	....		.008	250
Total	....		.366	4,921
Dinner.				
Broiled beefsteak	2	0	.366	1,790
Baked potatoes *a*	1	8	.025	465
Onions	2	0	.030	430
Bread		12	.071	910
Butter		3	.001	660

a Composition of cooked material.

MENU IV.—*For family equivalent to four men at moderate muscular work*—Continued.

Food material.	Weight.		Protein.	Fuel value.
Dinner—Continued.				
Baked apples:	*Lbs.*	*Oz.*	*Pounds.*	*Calories.*
Apples	1	0	0.004	255
Sugar		2	....	235
Cream		4	.006	228
Total			.503	4,973
Supper.				
Oyster stew:				
1 pint oysters	1	0	.060	230
1 pint milk	1	0	.033	325
Butter		2	.001	440
Crackers		6	.038	740
Bread		8	.047	610
Butter		2	.001	440
Currant jam		6	.004	546
Cake		8	.032	688
Tea			.008	250
Total			.224	4,275
Total per day			1.093	14,168
Total for one man			.275	3,542

The weights of fish, meats, and vegetables given in the menus are for these articles as found in the market. The fish and meats will include, as a rule, more or less bone, and the vegetables considerable skin and other parts, which are inedible and are rejected. In estimating the nutrients allowance is made for what has been found to be the average proportion of bone in different cuts of meats. In vegetables it is assumed that from one-sixth to one-fifth will be rejected in preparing them for the table. The weights of the breakfast cereals are for these in the dry condition before cooking.

The values given for tea or coffee are obtained by taking account of the sugar and milk or cream consumed with them. The infusion of tea or coffee contains little, if any, nutritive material. The value of tea and coffee in the diet depends upon their agreeable flavor and mild stimulating properties.

The calculations of the quantities of nutrients contained in the different foods are based upon the average percentage composition of these materials. The fats and carbohydrates in the different food materials are not shown in the menus. The quantity of protein and the fuel value of the food are the values which are of special interest. The fuel value of the fats and carbohydrates is, of course, included in the figures for fuel value given.

In the menus only such an amount of each food is indicated as might be completely consumed at each meal. Of course, in the ordinary household, there will usually be a rather larger quantity of the different dishes prepared than will be consumed at one meal, but the thrifty housekeeper will see to it that what is not used at one meal will be utilized for another.

It is not expected that each meal or the total food of each individual day will have just the amounts of protein and fuel ingredients that make a well balanced diet. The body is continually storing nutritive materials and using them. It is a repository of nutriment which is being constantly drawn upon and as constantly resupplied. It is not dependent any day upon the food eaten that particular day. Hence an excess one day may be made up by a deficiency the next or vice versa. Healthful nourishment requires simply that the nutrients as a whole during longer or shorter periods should be fitted to the actual needs of the body.

It will be seen that in each of the menus suggested fish occurs in at least two meals. However, in no case is the amount greater than experience has shown may occur in actual dietaries.

It is not the intention to suggest that a diet containing such quantities of fish be followed every day, but rather to show that fish may be readily combined with other food materials to supply the protein and energy required. While it may profitably be used more frequently in many families than is at present the case, this is a matter of individual taste.

The menus attempt to cover, as regards fish and other materials, a range in variety and combination such as might be found in an average well-to-do household. Individual tastes vary so much that no combination which could be selected would meet them all.

Nothing has been said of the cost of the foods used in the menus. All foods vary in price in different localities, and this is especially the case with fish. In general, it may be said that a large variety of fruits, vegetables, etc., increases the cost of a diet out of proportion to the nutritive material furnished. Such foods, however, are valuable, since they possess agreeable flavor and so render the diet appetizing. It is also generally believed that the acids, salts, and similar materials in fruits and vegetables are of value in maintaining the body in health. The income of the purchaser should determine how varied the diet may be.

POSSIBLE DANGERS FROM EATING FISH.

In view of statements of a popular nature which have been made on the dangers from eating poisonous fish or from ptomaines contained in fish, a few words summarizing the actual knowledge on these topics seem desirable.

There are several species of fish which are actually poisonous. Few of them, however, are found in the United States, and the chances of their being offered for sale are very small. Such fish are mostly confined to tropical waters.

Fish may contain parasites, some of which are injurious to man. These are, however, destroyed by the thorough cooking to which fish is usually subjected.

Ptomaines are poisonous bodies due to the action of micro-organisms. They are chemical compounds of definite composition and are elaborated by micro-organisms breaking down the complex ingredients of animal tissues, just as alcohol is due to the action of yeasts breaking down sugar, or as acetic acid is due to the action of *Mycoderma aceti* breaking down alcohol. The formation of ptomaines quite generally, although not always, accompanies putrefaction (often in its early stages), and therefore great care should be taken to eat fish only when it is in perfectly good condition. Fish which has been frozen and, after thawing, kept for a time before it is cooked, is especially likely to contain injurious ptomaines.

Canned fish should never be allowed to remain long in the can after opening, but should be used at once. There is some possibility of danger from the combined action of the can contents and oxygen of the air upon the lead of the solder or the can itself. Furthermore, canned fish seems peculiarly suited to the growth of micro-organisms when exposed to the air.

Finally, fish offered for sale should be handled in a cleanly manner and stored and exposed for sale under hygienic conditions.

Oysters when "floated" or "fattened" should never be placed in water contaminated by sewage. Severe illness and death have resulted in a number of cases from eating raw oysters contaminated with sewage containing typhoid fever germs.

It is only just to say that the dangers from parasites, micro-organisms, ptomaines, and uncleanly surroundings are not limited to fish. Under conditions which favor the growth of the micro-organisms, meat and other highly nitrogenous animal foods undergo decomposition resulting in the formation of ptomaines. Animal parasites may be acquired from flesh of various kinds if not thoroughly cooked, provided of course the flesh is infested. This danger is reduced by proper inspection. Vegetable foods also may become contaminated in various ways. The importance of measures to secure pure and wholesome food can hardly be overstated. The best interests of the people undoubtedly demand a strict and impartial supervision by public officers of the sale of food products.

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The following is a list of the Farmers' Bulletins available for distribution, showing the number, title, and size in pages of each. Copies will be sent to any address on application to Senators, Representatives, and Delegates in Congress, or to the Secretary of Agriculture, Washington, D. C.:

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U. S. DEPARTMENT OF AGRICULTURE.

FARMERS' BULLETIN No. 86.

THIRTY POISONOUS PLANTS

OF

THE UNITED STATES.

BY

V. K. CHESNUT,
Assistant Botanist, U. S. Department of Agriculture.

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LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Division of Botany,
Washington, D. C., October 31, 1898.

Sir: I have the honor to submit herewith for publication as a Farmers' Bulletin a manuscript by Mr. V. K. Chesnut, assistant botanist, entitled Thirty Poisonous Plants of the United States. In July, 1898, the Division of Botany issued as Bulletin No. 20 a report by Mr. Chesnut entitled Principal Poisonous Plants of the United States. The publication of that bulletin, however, instead of satisfying the demand for information on poisonous plants has increased it, and in order to supply the innumerable requests received since its appearance, it has seemed desirable to republish the information which it contained, in a condensed, less expensive, and more popular form. In the present publication several of the less important poisonous plants have been stricken out, while only a small amount of new matter has been added. Physiological, botanical, and chemical technicalities have been omitted, as well as most of the matter relating to remedies. The omission of remedies has been due to the difficulty of imparting exact knowledge of this subject in sufficiently condensed form, and especially to a desire to avoid the danger involved in the application, by inexperienced persons, of remedies which themselves might be fatally poisonous if improperly used. Only under the most desperate circumstances should such remedies be administered by anyone except a physician.

Respectfully,

Frederick V. Coville, *Botanist.*

Hon. James Wilson, *Secretary.*

CONTENTS.

	Page.
Introduction	3
Fly amanita (*Amanita muscaria*) (fig. 1)	4
Death cup (*Amanita phalloides*) (fig. 2)	6
American false hellebore (*Veratrum viride*) (fig. 3)	7
Pokeweed (*Phytolacca decandra*) (fig. 4)	9
Corn cockle (*Agrostemma githago*) (fig. 5)	10
Dwarf larkspur (*Delphinium tricorne*) (fig. 6)	11
Wyoming larkspur (*Delphinium geyeri*)	12
Purple larkspur (*Delphinium menziesii*)	12
Black cherry (*Prunus serotina*) (fig. 7)	13
Woolly loco weed (*Astragalus mollissimus*) (fig. 8)	14
Stemless loco weed (*Aragallus lambertii*) (fig. 9)	16
Rattlebox (*Crotalaria sagittalis*) (fig. 10)	16
Caper spurge (*Euphorbia lathyris*) (fig. 11)	17
Snow on the mountain (*Euphorbia marginata*) (fig. 12)	18
Poison ivy (*Rhus radicans*) (fig. 13)	19
Poison oak (*Rhus diversiloba*) (fig. 14)	21
Poison sumac (*Rhus vernix*) (fig. 15)	21
Red buckeye (*Aesculus pavia*)	22
Water hemlock (*Cicuta maculata*) (fig. 16)	23
Oregon water hemlock (*Cicuta vagans*) (fig. 17)	24
Poison hemlock (*Conium maculatum*) (fig. 18)	25
Broad-leaf laurel (*Kalmia latifolia*) (fig. 19)	26
Narrow-leaf laurel (*Kalmia angustifolia*)	27
Great laurel (*Rhododendron maximum*)	28
Staggerbush (*Pieris mariana*) (fig. 20)	29
Branch ivy (*Leucothöe catesbaei*) (fig. 21)	29
Jimson weed (*Datura stramonium*) (fig. 22)	29
Black nightshade (*Solanum nigrum*) (fig. 23)	30
Bittersweet (*Solanum dulcamara*)	31
Sneezeweed (*Helenium autumnale*) (fig. 24)	32

THIRTY POISONOUS PLANTS OF THE UNITED STATES.

INTRODUCTION.

In view of the frequent complaints made by farmers and others against various plants as poisonous to man and to animals, it is surprising that no illustrated account has been published of our harmful native species in such form as to be readily accessible to those who are most likely to suffer from their effects.

Statistics in regard to poisonous plants are lacking on account of a general ignorance of the subject, and it is therefore impossible to form even an approximate estimate of the amount of damage done by them. The various species of water hemlock (Cicuta) kill a number of children each year. In the State of New Jersey two quadruple cases of water hemlock poisoning were reported during the spring of 1896, which resulted fatally to two of the eight individuals affected. The number of cattle killed by one species of Cicuta in Oregon alone is estimated to be over 100 per annum. The damage caused by the well-known loco weed in Colorado was so large that the State paid out nearly $200,000 in bounties in an effort, unfortunately ineffectual, to exterminate the pest. The distress caused by poison ivy is being constantly experienced by thousands of individuals.

The Division of Botany has for the last three years been collecting general and specific information concerning poisonous plants, both from general works and special articles and by experimental investigation. From a more recent date investigations have been made of cases of poisoning which have been reported in the newspapers or by the regular correspondents and friends of the Division. By communicating with the physicians who had charge of each case, accurate and full data were obtained with regard to many plants.

All poisonous plants are not equally injurious to all persons, nor to all forms of life. The most familiar illustration of this fact is to be found in the action of poison ivy. It has no apparent external effect upon animals, and a few of them, such as the horse, mule, and goat, eat its leaves with impunity. It acts upon the skins of a majority of persons, but with varying intensity. Many people are probably wholly immune, but some lose their resistant power in middle life; others have been known to attain immunity from it to a very considerable degree. There is a similar variability in the effects of poisonous plants taken internally. The qualifications involved in the definition of a poisonous plant are numerous, and can not well be introduced into this report. It may suffice here to say that death in some cases is attributable not to any poison which the plant contains, but to immoderate or incautious eating, or to mechanical injury, such as is produced in horses by the hairs of crimson clover, which under certain conditions accumulate in large balls and obstruct the intestines, or to the effect of parasitic growths, such as ergot occurring on rye. Neither the clover nor the rye is poisonous.

Excluding all that operate in these ways, there is still a large number of poisonous plants which, on account of their limited area of growth, and sometimes of the uncertainty of our knowledge concerning their evil effects, are comparatively little known. In the present bulletin, however, it is possible to consider only those which are well known to be poisonous.

FLY AMANITA.

Amanita muscaria (L.) Fr.

Other names: Fly fungus; fly agaric; fly killer; deadly amanita; false orange amanita. (Fig. 1.)

Description.—The amanitas form the most typical genus of that group of fleshy fungi which bear radiating plates or gills on the under surface of the cap. In the early stages of growth the amanitas are egg-shaped and are entirely enveloped by a white fleecy or cobwebby covering, which is ruptured as the stem lengthens. In a few species this covering adheres in loose, corky patches to the top of the cap, as seen in fig. 1, but sometimes it slips away from the cap entirely and forms a more or less continuous sheathing cup at the base of the stem, as shown in fig. 2. This fleecy covering and the invariably bulbous base of the stem are the most important characteristics of the genus, while the varying appearance of the former after rupture helps to distinguish the species. These features are well pronounced as a rule, but sometimes it requires some searching to find the cup.

Besides the general envelope there is also a secondary one, which at first covers the gills, extending from the stem outward in all directions horizontally to the rim of the cap. This breaks away from the cap before maturity and frequently forms a conspicuous collar about the upper part of the stem. The spores, and usually the gills also, are white.

The fly amanita is a handsome, robust species, 4 to 16 inches high. It is singularly free from larval pests and the usual signs of decay, and is highly attractive in appearance, taste, and smell. In its early stages the shape of the cap is very strongly convex, but by gradual expansion it becomes flat and even concave. It is invariably warty. In color it varies from nearly white through all shades of yellow to a bright red. As a rule, it is more reddish in the center and light yellow outward, but sometimes the color is uniform throughout. The enlarged base is marked with short, stubby projections of the skin, which are generally replaced upward along the lower part of the stem by soft, flexible shavings, as seen in the figure. The general shape of the plant is very much like that of the orange amanita (*Amanita caesarea*), but it differs conspicuously in the absence of a cup and in the possession of white instead of yellow gills and stems. It differs also in usually having a warty instead of a smooth cap. Both grow in pine and oak forests from spring to autumn, but the edible species does not appear so late in the autumn as the other. From the common mushroom (*Agaricus campestris*) the fly amanita is easily distinguished by having white instead of purple gills and spores, by its warty cap and bulbous stem, and by its place of growth—the meadow mushroom never appearing in forests. The fly amanita is abundant in several localities in the United States.

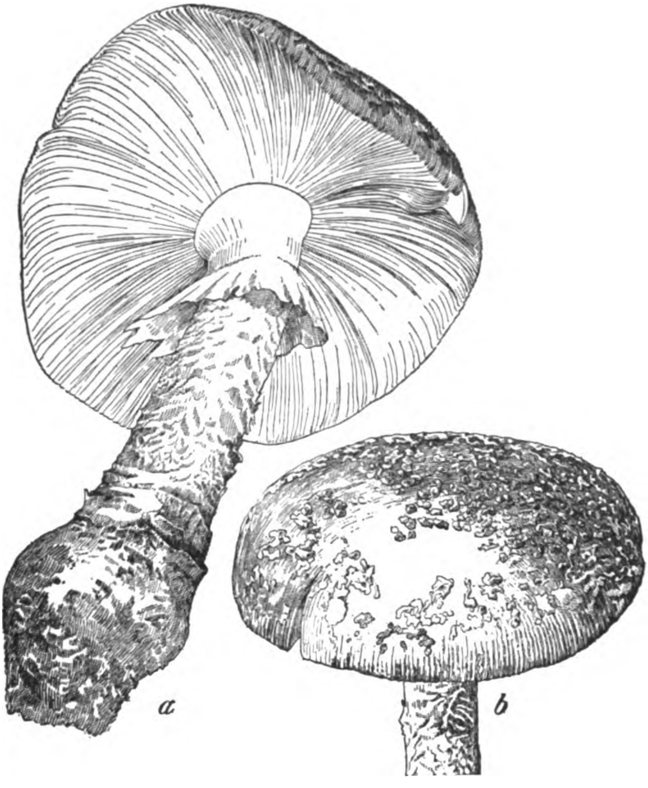

Fig. 1.—Fly amanita (*Amanita muscaria*): *a*, mature plant; *b*, top view of cap, showing corky patches—both one-half natural size.

Poisonous character.—It is the best known of all the poisonous species. As a fly poison it has been used in Europe for hundreds of years, and the origin of its use in northeastern Asia as an intoxicant is probably not much more modern. Poisoning is, however, not so frequently caused by it as by the closely related and more poisonous death cup (*Amanita phalloides*), yet many cases have been recorded. Cattle are poisoned as well as men, and it is supposed that their flesh is thus rendered unwholesome.

Symptoms of poisoning.—The symptoms come on generally within two hours after the fungus is eaten, and consist in a less rapid beating of the heart and an extreme difficulty in breathing. After two or three hours there is a profound stupor, often preceded or accompanied by cold sweats and nervous phenomena—such as giddiness, double vision, and lockjaw. Vomiting sometimes gives relief to the patient, but it is often difficult to produce this effect after stupor has set in, even with the most powerful emetics. This condition may last from eight to ten hours in milder cases, and one or two days in more serious cases. Death follows in from eighteen hours to two or three days, from a gradual weakening and a final stoppage of the heart's action.

There is very little danger of finding either the fly amanita or the death cup (a description of which follows) mixed with the meadow mushrooms sold by regular dealers or brought into market by people who make it a business to do so, but diligence should be maintained by market inspectors in scrutinizing all new kinds of fungi brought in for general sale.

DEATH CUP.

Amánita phalloides (L.) Fr.

Other names: Poison amanita; bulbous amanita. (Fig. 2.)

Description and where found.—This is not so large or brightly colored as the fly amanita, but is nevertheless decidedly attractive to the inexperienced and experimenting epicure. When fresh it has neither a disagreeable odor nor taste, nor has it any ill appearance due to the presence of larvæ. It grows from 3 to 6 or 8 inches high, and has a smooth, satiny cap, which is strongly convex at first, finally becoming flat or slightly concave. It is usually white or straw-colored, but may be green, light brown, yellow, or even spotted when found growing in dense shade. The stem is white and nearly smooth. The covering present in the fungus when young almost invariably slips away from the cap in this species at maturity and forms a more or less conspicuous cup at the base of the stem, as shown in figure 2. In dry weather it sometimes partially adheres to the cap. The cup is, however, invariably present. In connection with the white gills and spores and the bulbous base, it is the distinguishing feature of the species. In general shape the death cup is somewhat like the common mushroom, but it is very much more like another species, the smooth lepiota (*Lepiota naucina*), which is considerably sought after by expert epicures. The lepiota, like the death cup, has a smooth, satiny cap, white gills, and white spores, but it is distinguished by the absence of a sheathing cup and by the ball-and-socket attachment of the stem to the cap, as well as by its occurrence chiefly in meadows. From the common mushroom the death cup may be at once distinguished by its cup, by its white gills and spores, and by its growing in woods instead of in meadows. The death cup is the most poisonous of all the fleshy fungi. It is found usually in pine forests, where it often grows in greater abundance than any other species of fungus. Sometimes, however, it encroaches upon lawns near the borders of woods. The plant is recorded as growing in California and in various parts of the Eastern and Middle States. In the vicinity of Washington, D. C., it is exceedingly abundant in late autumn.

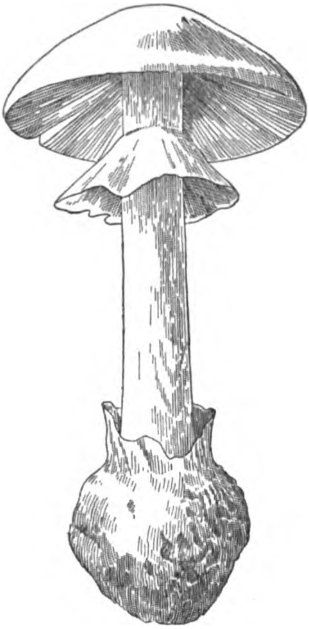

FIG. 2.—Death cup (*Amanita phalloides*), one-half natural size.

Poisonous character.—A large number of cases of poisoning have been attributed to this fungus in ancient as well as in modern times. In most of them the plant was taken to be an edible fungus. In a few instances the mere handling of the plant caused serious trouble. A third part of an uncooked medium-sized cap proved fatal to a boy 12 years of age.

The symptoms are characteristic; no bad taste warns the victim, and usually the first effects do not appear until from nine to fourteen hours after eating. There is then considerable pain, and there may be cramps in the legs and other nervous phenomena, such as convulsions and even lockjaw. In a few cases there are spasms. The pulse is weak and either quick or slow in its action. The pupils of the eyes are sometimes dilated. The abdominal pain is rapidly followed by nausea, vomiting, and extreme diarrhea, the discharges assuming the peculiar "rice water" condition characteristic of cholera. The latter symptoms are persistently maintained, generally without loss of consciousness, until death ensues, as it does in from two to four days.

The vernal amanita or destroying angel (*Amanita verna*) is regarded by some experts as identical with the death cup. It has the same poisonous action.

AMERICAN FALSE HELLEBORE.

Veratrum viride Ait.

Other names: American white hellebore; white hellebore; false hellebore; swamp hellebore; Indian poke; meadow poke; poke root (in N. H.); Indian uncus; puppet root; earth gall; crow poison; devil's bite; duckretter; itch weed; bugbane; wolfsbane; bear corn. (Fig. 3.)

Description and where found.—A stout, herbaceous, simple-stemmed perennial, 2 to 7 feet high, with a fleshy root 1 to 3 inches long, large plaited stemless leaves of varying size, and a large, loose, terminal cluster of yellowish-green flowers which blossom from May to July. The plant is native to the United States, where it grows abundantly in wet meadows and along mountain brooks throughout New England; southward in cold localities through New York and Delaware to Virginia, and in the Alleghany Mountains to Georgia; westward in northern Wisconsin, the mountains of Oregon, Washington, and Idaho, and in Alaska.

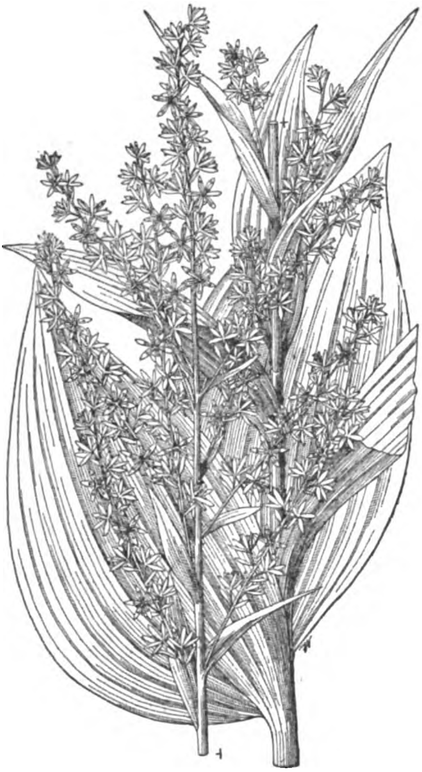

FIG. 3.—False hellebore (*Veratrum viride*), one-third natural size.

Poisonous character.—Cases arise mainly from overdoses in medicine, but instances of accidental poisoning are reported for man and for various animals and birds. The seeds have been specially mentioned as poisonous to chickens. Some animals, such as the horse, are poisoned by eating the leaves, but animals such as the sheep and elk, which chew the cud, seem to relish the plant, and eat it with apparent impunity. The root has been eaten with fatal results by human individuals. One instance is recorded where all the members of a household were poisoned by eating the young leaves, which were mistaken for those of marsh marigold (*Caltha palustris*) and prepared for food.

The poison operates chiefly against the action of the heart and spinal cord, both of which it tends to paralyze. It has also a violent, although somewhat tardy, emetic and cathartic effect, a property which is often effective in expelling the poison from the system before it accomplishes its deadly work.

Symptoms.—The chief effects on the system are burning in the throat, an increased flow of saliva, defective vision, vomiting, diarrhea, severe headache, dizziness, weak pulse, labored breathing, and profound prostration. Death is caused by paralysis of the heart.

POKEWEED.

Phytolacca decandra L.

Other names: Poke; poke root; garget; pigeon berry; cocum; jalap; skoke; American nightshade; crowberry; cancer root; chongras (La.); redweed; red-ink plant; pocan bush. (Fig. 4.)

Description and where found.—A smooth, rank, succulent perennial, 6 to 9 feet high, with a thick half-woody root, purplish stems, large alternate leaves, and numerous elongated clusters of small greenish-white flowers, which blossom throughout the summer, and are followed in autumn by shining purple-black berries. The plant is native to the United States, and grows in rich, moist soils, especially as a weed in cultivated and waste grounds, from Maine and northern Illinois to Florida, and westward to Texas. eastern Kansas. and southern Minnesota.

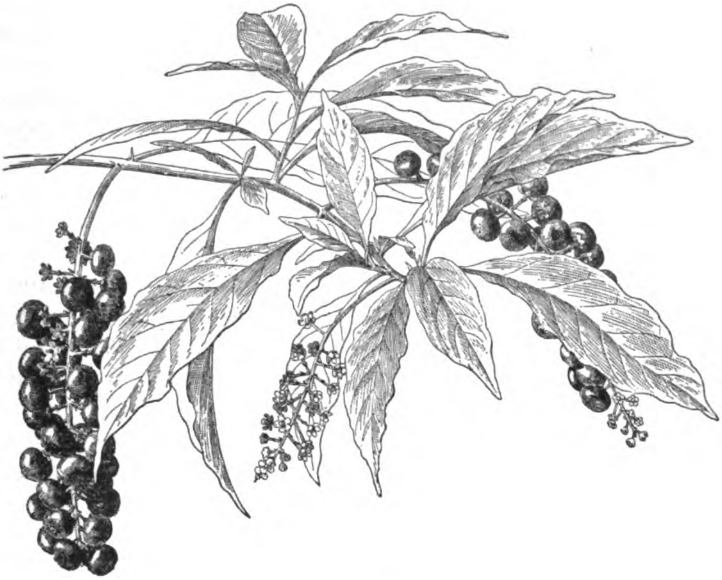

FIG. 4.—Pokeweed (*Phytolacca decandra*), one-half natural size.

Uses.—The pokeweed is a well-known plant and has many household uses, but some chemical or mechanical manipulation seems necessary to prevent ill effects when it is eaten. The root and the alcoholic extract of the fruit are quite commonly used as a household remedy for the itch and other skin diseases and for rheumatism. The fresh shoots are rather widely esteemed as a substitute for asparagus, but in the preparation considerable care is exercised to reject the root, for small quantities impart a bitter taste to the mess, and larger amounts will prove dangerous. The water in which the shoots are first boiled is also rejected on account of the poisonous substance contained in it.

The flesh of the berries is eaten with impunity by some birds, but its use by human beings can not be recommended.

Poisonous character.—Most instances of poisoning arise from overdoses when the plant has been used as a medicine, but there are also accidental cases due to the eating of the root, which has been variously mistaken for that of the parsnip, artichoke, and horse-radish. A few fatal cases of poisoning of children have been attributed to the fruit, but whether death was really due to the seed or the pulp is somewhat uncertain. The evidence is chiefly against the seed, for it is known to contain a poisonous substance.

Pokeweed is a violent but slow-acting emetic, vomiting beginning only after about two hours. It also affects the nerves and muscles, producing retching, spasms, severe purging, and sometimes convulsions. Death is apparently due to the paralysis of the respiratory organs.

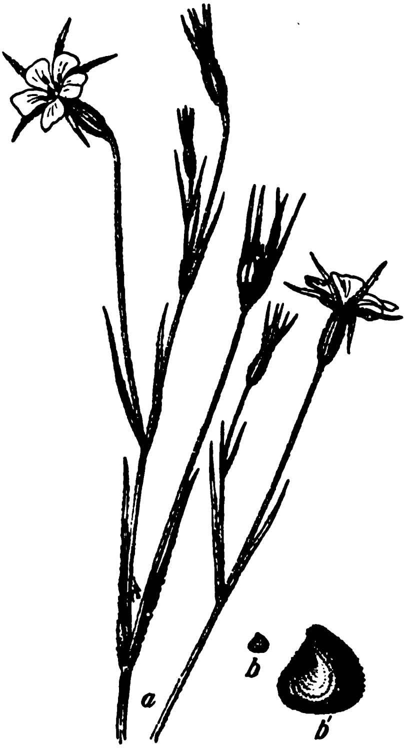

FIG. 5.—Corn cockle (*Agrostemma githago*): *a*, sprays showing flowers and seed capsule, one-third natural size; *b*, seed, natural size; *b'*, seed, four times natural size.

CORN COCKLE.

Agrostemma githago L.

Other names: Cockle; rose campion; bastard nigelle; old maid's pink (N. H.); mullein pink (Nova Scotia); licheta (Vt.); crown of the field. (Fig. 5.)

Description and where found.—A whitish, woolly annual, 1 to 3 feet high, with an erect stem, showy, violet-red flowers, and numerous rough, black, irregularly rounded seeds.

The corn cockle is a noxious weed in Europe, and in the United States it is now generally introduced in grain fields from Maine to North Dakota, southward through eastern Kansas to Louisiana and Florida; sparingly in Wyoming and California, and scarcely at all in the dry regions extending eastward from California to Texas and eastern Kansas.

Poisonous character.—The poisonous constituent is very freely soluble in water, and possesses a sharp, burning taste. It has no odor, but when inhaled in the smallest quantity it produces violent sneezing. When briskly shaken with water it froths like soap. The poison is found in nearly all parts of the plant, but mainly in the kernel of the seed.

Ways of poisoning.—Cases of poisoning have been noted among all sorts of poultry and household animals, but are rarely due to any portion of the plant as found growing in the field. The poisoning is generally produced by a poor grade of flour made from wheat containing cockle seeds. Machinery is used to remove these seeds from the wheat, but the difficulty of separating them is so great that the result is not entirely accomplished. The quantity remaining determines the grade of the flour in this particular regard. In European countries it sometimes amounts to 30 or 40 per cent, but this quality is sent out only by ignorant or unscrupulous dealers, or is intended for consumption by animals only. Flour containing a smaller amount has often been made into bread and eaten, sometimes with fatal results, the baking not always being sufficient to decompose the poison. The effect may be acute, or, if a small quantity of the meal is eaten regularly, it may be chronic. In the latter case it is sometimes known as a disease under the name of "githagism."

Symptoms.—The general symptoms of acute poisoning are the following: Intense irritation of the whole digestive tract, vomiting, headache, nausea, vertigo, diarrhea, hot skin, sharp pains in the spine, difficult locomotion, and depressed breathing. Stupor sometimes sets in, and it may be followed by death. Chronic poisoning has not been closely studied in man, but experiments upon animals show chronic diarrhea and gradual depression, the animal losing vigor in breathing and in muscular movements until death ensues.

Corn cockle meal is easily detected in second and third class flour by the presence of the black, roughened scales of the seed coat. These are sure to occur if the flour has not been well bolted. Its presence is otherwise detected by the peculiar odor produced when the meal is moistened, and by chemical tests with iodine.

Wheat containing corn cockle seeds should be rejected for planting.

DWARF LARKSPUR.

Delphinium tricorne Michx.

Other name: Stagger-weed (Ohio). (Fig. 6.)

Description.—The genus Delphinium, formed by the larkspurs, is composed of erect herbs, with palmately lobed leaves, and an elongated cluster of showy flowers. These are commonly blue, and are further characterized by the absence of green parts, and the presence of a peculiar spur-like appendage.

There are over 25 species native to the United States. Few have a very wide distribution, but some of the Western species are extremely abundant in their natural place of growth. They have a general reputation of being poisonous to cattle.

The dwarf larkspur is a smooth, simple-stemmed perennial, 6 to 12 inches high, with a tuberous root, deeply 5-parted leaves, and a long, loose cluster of blue (sometimes white) flowers, which appear in April and May. It grows in clayey soil and open woods, from Pennsylvania and the mountains of North Carolina to southern Minnesota. It is especially reported from Ohio as fatal to cattle in April, when the fresh leaves appear.

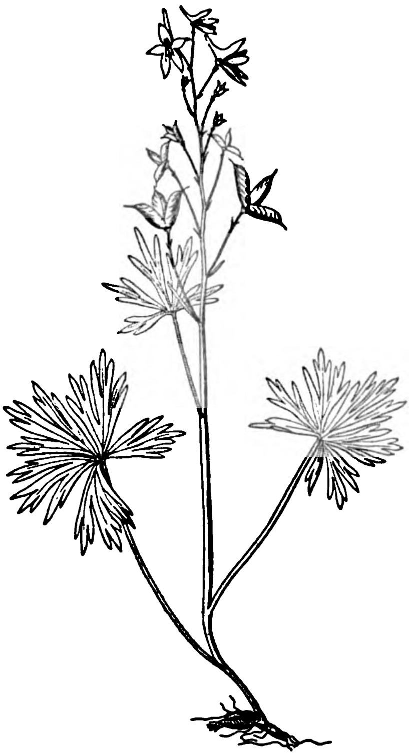

Fig. 6.—Dwarf larkspur (*Delphinium tricorne*), one-third natural size.

WYOMING LARKSPUR.

Delphinum geyeri Greene.

Other name: Poison weed.

Description and where found.—A somewhat hairy perennial, 10 to 20 inches high, with a large spheroidal tuft of rather thick, dull-green leaves, and a central column of deep azure-blue flowers. A common high prairie plant of Wyoming and northern Colorado. It is reported to be the most troublesome of the poisonous plants of Wyoming. Ranchmen suffer considerable loss from it, especially in early spring, when the dark-green tufts of foliage are conspicuous features of the otherwise dry and barren landscape.

PURPLE LARKSPUR.

Delphinium menziesii DC.

Description and where found.—A somewhat hairy, tuberous-rooted perennial, about a foot high, with a basal cluster of finely divided, long-stemmed leaves, and a single column of showy blue flowers, which appear at any time between April and July. The flowers are few in number, but are extra large, being from 1 to 1½ inches broad. This species is found native on hillsides from the vicinity of San Francisco to British Columbia and eastward as far as South Dakota. In Montana it is very common throughout the State.

Poisonous character.—The percentage of fatal cases in cattle which have eaten this and other larkspurs is said to be small. A rough estimate by a cattleman places it at about 20 per cent for one species of the group, when the animals are not properly treated, and 5 per cent otherwise. This is probably a low estimate, however, for in a case of poisoning from *D. menziesii* that occurred in Montana in May, 1897, and was reported by Dr. E. V. Wilcox, nearly 600 sheep were affected, 250 of which died.*

It is an excellent precaution to allow animals in pastures containing larkspur only when well fed, and then only for short periods, until they become thoroughly familiar with the deleterious nature of the plants.

The tall mountain larkspur (*Delphinium trolliifolium*), sometimes known as cow poison, grows in moist, shady places from Monterey, Cal., to British Columbia. Reports of poisoning come from California and Oregon. The poisonous qualities of this species have, however, been considerably questioned.

A lavender-colored, fleshy-rooted larkspur (*Delphinium recurvatum*) which grows in moist saline soils south of San Francisco and Stockton, in California, is particularly reported as fatal to animals in San Luis Obispo County.

The seed of the European stavesacre (*Delphinium staphisagria*) has long been regarded as a powerful poison. The seed of the commonly introduced larkspur (*D. consolida*) is regarded as less poisonous; the leaf is reputed to be poisonous to cattle in Europe. The leaf of the stavesacre has only recently been shown to be poisonous. The properties of the roots of these and other species are not well known. Little or no attention has yet been paid by American chemists to the native larkspurs, hence it is not known how poisonous they are in comparison with European.

BLACK CHERRY.

Prunus serotina Ehrh.

Other names: Wild black cherry; wild cherry; rum cherry; whisky cherry. (Fig. 7.)

Description and where found.—A valuable forest tree, 60 to 80 feet high, with thin, reddish-brown, scaly bark, tapering, saw-edged leaves, cylindrical clusters of small white flowers appearing in April and May, and shining-black, edible fruit, about a quarter of an inch in diameter. It grows abundantly in forests in the Middle Atlantic and Ohio River States; less commonly in woods and in the open country in the southern New England and Gulf States, and westward from Illinois to South Dakota, eastern Nebraska, and Arkansas. As an ornamental and shade tree it is cultivated extensively in Wyoming and Colorado, and eastward to the Atlantic.

Fruit.—The fruit is rather agreeable, being but slightly bitter and astringent in taste. In some localities it is much used to flavor liquor.

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* Since the above was in press, Dr. S. B. Nelson, Professor of Veterinary Sciences in the Washington State Agricultural College, has published (Bull. No. 22, Bureau of Animal Industry, U. S. Department of Agriculture) the results of an experiment made by himself, in which as much as 24¾ pounds of the fresh leaves of this plant was fed to a sheep within a period of five days without any apparent ill effect. An experiment made by Dr. Wilcox (Bull. No. 15, Montana Agricultural Experiment Station) shows that the extract from less than an ounce of the dried leaves killed a yearling lamb in two hours, the dose having been given by way of the mouth.

Ways of poisoning.—Poisoning is frequently caused in cattle by eating the wilted leaves from branches thrown carelessly within their reach or ignorantly offered as food. Children occasionally die from eating the kernels of the seed or from swallowing the fruit whole.

Symptoms.—The prominent symptoms of black-cherry poisoning observed in cattle are labored breathing, diminished pulse, numbness, protruding eyeballs, convulsions, and death from paralysis of the lungs. In some cases there is considerable frothing at the mouth; in all there is a very perceptible odor of prussic acid in the breath.

The freshly cut branches of the trees should in no case be thrown where cattle can get at them.

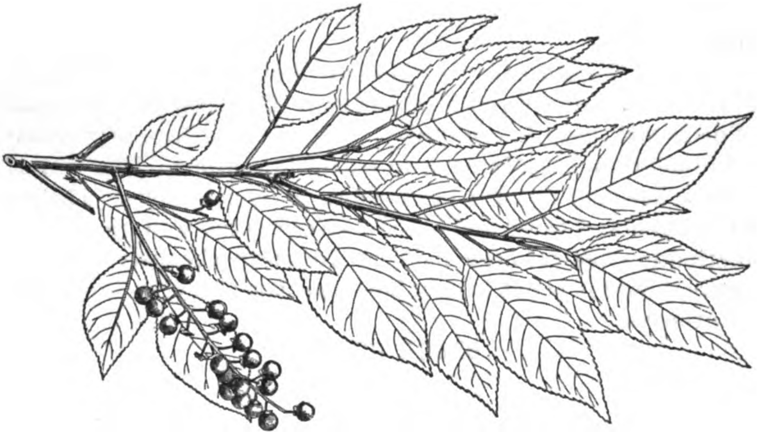

FIG. 7.—Black cherry (*Prunus serotina*), one-third natural size.

WOOLLY LOCO WEED.

Astragalus mollissimus Torr.

Other names: Loco weed; crazy weed. (Fig. 8.)

Description and where found.—A silvery-white, silky-leaved perennial 8 to 12 inches high, with an abundance of soft foliage springing out in a cluster from a short central stem close to the ground. The flowers are pea-shaped and usually purple. The pod is distinctly two-celled. This plant is native to the Great Plains region, extending from western Texas and New Mexico northward to South Dakota and Wyoming, being most abundant in Colorado and in the western part of Nebraska and Kansas. It grows both on the open prairie and on rocky hillsides.

How stock are affected.—Horses, cattle, and sheep are affected by loco, but the principal damage is done to horses. The effect is not acute, but in its slow progress simulates diseases caused by bacteria, worms, or other parasites or such as are caused in man by the continued use of alcohol, tobacco, or morphine. Two stages are recognized. The first, which may last several months, is a period of hallucination or mania accompanied by defective eyesight, during which the animal may perform all sorts of antics. After acquiring a taste for the plant it refuses every other kind of food, and the second stage is ushered in. This is a lingering period of emaciation, characterized by sunken eyeballs, lusterless hair, and feeble movements. The animal dies as if from starvation, in periods ranging from a few months to one or two years.

Damage done.—The damage done to the live-stock business by this weed is immense. As mentioned in the introduction, the State of Colorado paid out nearly $200,000 in bounties between 1881 and 1885 in an attempt to exterminate it.

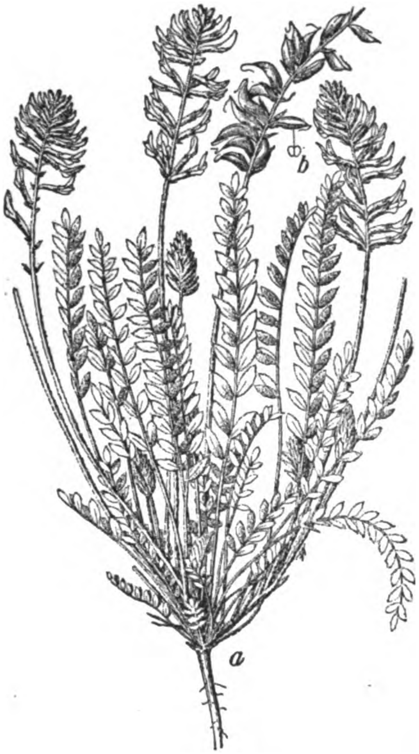

FIG. 8.—Woolly loco weed (*Astragalus mollissimus*): *a*, whole plant; *b*, cross section of pod—both one-third natural size.

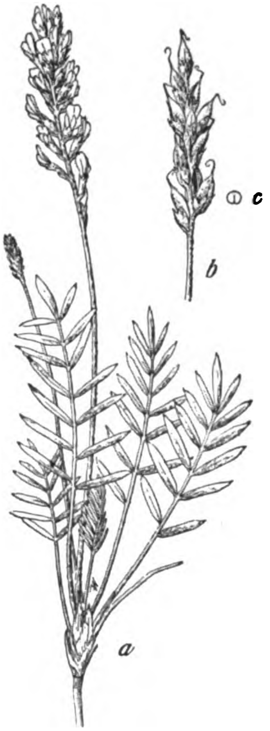

FIG. 9.—Stemless loco weed (*Aragallus lambertii*): *a*, flowering plant; *b*, seed pods; *c*, cross section of seed pod—all one-third natural size.

This genus contains a large number of species, and it is quite probable that many of these should be considered to be poisonous where they grow over wide areas of pasture land, and are green at periods when there is but little green grass. Over a half dozen have been reported to the Department of Agriculture as highly detrimental to the stock industry.

STEMLESS LOCO WEED.

Aragallus lambertii (Pursh) Greene.

Other names: Loco weed; crazy weed; Colorado loco vetch. (Fig. 9.)

Description and where found.—This differs from the true loco weed most conspicuously in its more erect and branchless habit, its longer leaflets, which are linear or oblong instead of ovate, and the one-celled seed pod. It ranges over the same territory as does the woolly loco weed, but extends farther, being found throughout the Great Plains from British America to Mexico, and it also ascends higher in the mountains, growing luxuriantly at Silver Cliff, in Colorado, at an altitude of about 8,000 feet.

Symptoms.—So far as has been observed, the symptoms of poisoning are identical with those produced by the preceding species. The two plants are considered to be equally prejudicial to the stock-raising interests of New Mexico.

RATTLEBOX.

Crotalaria sagittalis L.

Other names: Rattleweed; wild pea. (Fig. 10.)

Description and where found.—A hairy annual, 3 to 18 inches high, with simple undivided leaves, 1 to 2 inches long, and small, yellow pea-like flowers appearing in July. The seed pods are about an inch in length when mature, and are nearly black. They are much inflated, and as the walls are stiff and thin and very resonant, they make excellent miniature rattles when the seeds have become detached from their fastenings inside the pod. The rattlebox is native in low, sandy soils from the Atlantic westward to Minnesota and eastern Kansas; also in New Mexico. It is common in Connecticut, New Jersey, and North Carolina, and in some years is very abundant in bottom lands along the valley of the Missouri, in South Dakota and Iowa.

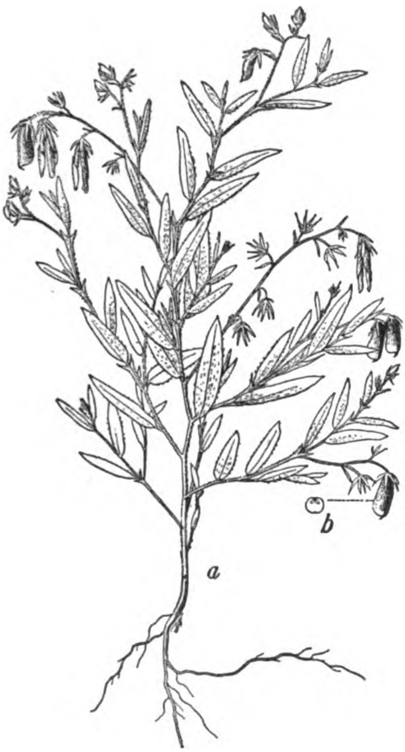

FIG. 10.—Rattlebox (*Crotalaria sagittalis*): *a*, whole plant; *b*, cross section of seed pod—both one-third natural size.

Poisonous character.—The poisonous constituent is unknown, but it resides both in the leaves and in the seeds. Horses, and sometimes cattle, are killed by eating grass or meadow hay mixed with the plant.

They are not poisoned so often by eating the plant in the field. Public attention was first called to the poisonous nature of rattlebox by Dr. Stalker, of Iowa, who in 1884, while investigating the cause of "bottom disease," then prevalent among horses in Iowa, was led to believe that it was mostly if not altogether attributable to this plant. Experiments were made which proved the supposition to be correct.

Symptoms.—As generally described from accidental cases, the symptoms are much prolonged, death resulting only after several weeks or months. There is a general decline of vigor, and a gradual loss of flesh as observed in the case of loco, with which this plant is closely related. The rattlebox does not, however, appear so often to produce the craziness characteristic of loco.

The percentage of rattlebox in meadow hay will be much reduced if the fields are burned over when the seeds mature the preceding summer. The growth of perennial grasses will not be materially affected thereby.

CAPER SPURGE.

Euphorbia lathyris L.

Other names.—Garden spurge; myrtle spurge; mole plant; mole weed; mole tree; gopher plant; antigopher plant; wild caper; caper bush; wolf's milk; springwort. (Fig. 11.)

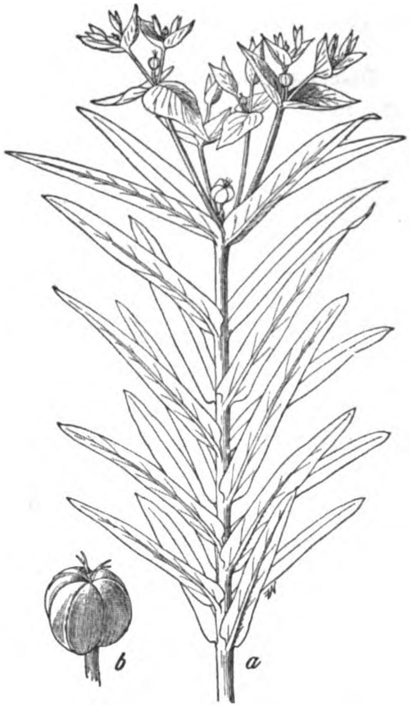

Fig. 11.—Caper spurge (*Euphorbia lathyris*): *a*, upper half of plant, one-third natural size; *b*, seed capsule, natural size.

Description and where found.—A smooth herbaceous, milky-juiced perennial, 2 to 3 feet high, with a stiff, erect stem, and opposite, four-ranked leaves, the lower of which are thick and oblong, the upper thin, broad, and heart-shaped. The flowers are greenish-yellow and rather small. The three-seeded fruit is conspicuous. It is a common garden plant, sparingly introduced in wet ground in California and Texas, and in the Atlantic States from New Jersey to West Virginia and North Carolina.

Poisonous properties.—The fresh milky juice is exceedingly acrid and the fruit is highly purgative and poisonous. When used as a household remedy it often provokes serious trouble. Women and children are not infrequently poisoned by handling the plant and getting the juice on the face. Cattle are quite resistant to its influence, but they are sometimes overcome. Goats will eat the plant extensively if nothing better presents itself, and it is said that their milk then possesses all of the venomous properties of the plant. When applied to the skin the juice causes redness, itching, pimples, and sometimes gangrene, the effect often lasting more than a week. The seed taken internally in overdose will inflame the mouth and stomach, and cause intense diarrhea and vomiting. If the dose is sufficient, there will be nervous disorders, unconsciousness, general collapse, and death.

SNOW ON THE MOUNTAIN.

Euphorbia marginata Pursh.

Description and where found.—An annual plant 2 to 4 feet high, differing most conspicuously from the preceding species in its more slender and less branching habit, and in having its upper leaves broadly margined with white. (Fig. 12.) Its general aspect is far more pleasing to the eye, and on this account it is more frequently gathered for decorative purposes. This spurge is a native weed of the Great Plains from Montana to Mexico, and is spreading eastward rapidly to Louisiana and through southern Minnesota and Missouri to Wisconsin, Illinois, and Indiana. It is cultivated considerably for ornament, especially in the Northern Atlantic States, where it has frequently escaped from cultivation. It has recently been introduced as a weed into Germany.

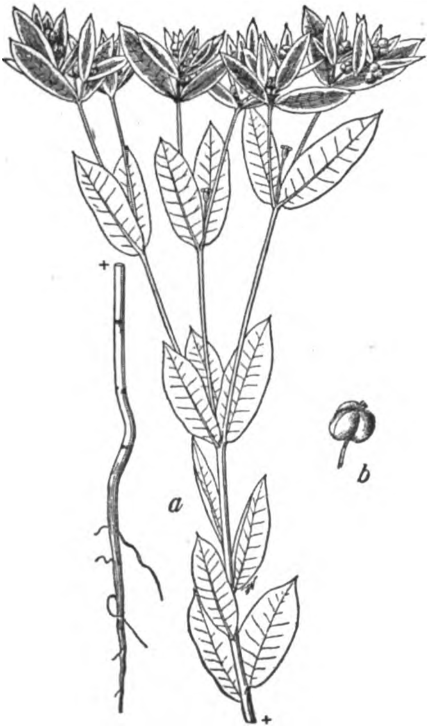

Fig. 12.—Snow on the mountain (*Euphorbia marginata*): *a*, whole plant, one-third natural size; *b*, seed capsule, natural size.

Poisonous property.—The poison of this plant reaches the stomach so far as known only through the eating of honey derived from its flowers. Large quantities of fall honey are annually made unsalable in localities where the plant grows in great abundance. The honey is hot and disagreeable to the taste, but does not appear to be a very serious poison, its effects being confined mostly to vomiting and purging. The milky juice, when it gets on the skin, very often causes an itching inflammation, accompanied by pimples and blisters which last for several days. The general effect is much like that observed in rhus poisoning, for which it is sometimes mistaken. This blistering action is, in fact, so decided that a few stock raisers in Texas use the juice to brand cattle, it being held by them to be superior to a red-hot iron for that purpose, because the scar heals more satisfactorily.

POISON IVY.

Rhus radicans L.

Other names: Poison oak; poison vine; three-leaved ivy; poison creeper; mercury or markry (N. H. and N. J.); black mercury (Me.); markweed (Me.); pickry (Me.). (Fig. 13.)

Description and where found.—A climbing or trailing shrub (sometimes erect), with variable three-foliate leaves, aerial rootlets, and greenish flowers, appearing in May and June. The smooth, waxy, white fruit often remains on the plant until late in winter. The leaves often resemble those of the box elder, as in the figure. They differ from those of the Virginia creeper in having only three leaflets instead of five. Poison ivy grows everywhere in open brush, in ravines, and on the borders of woods, and it is spread along roadsides and cultivated fields from seeds carried by crows, woodpeckers, and other birds that feed upon its fruit in winter. Through ignorance or carelessness, and at the imminent risk of causing great bodily discomfort to many persons, this vine is sometimes planted about suburban and even city residences for the sake of ornament. It occurs wild in abundance throughout the United States as far west as eastern Texas, eastern Kansas, and Minnesota, and in greater or less abundance throughout the less arid region of the West, with the exception of California and the western parts of Oregon and Washington, where it appears to be entirely replaced by *Rhus diversiloba.*

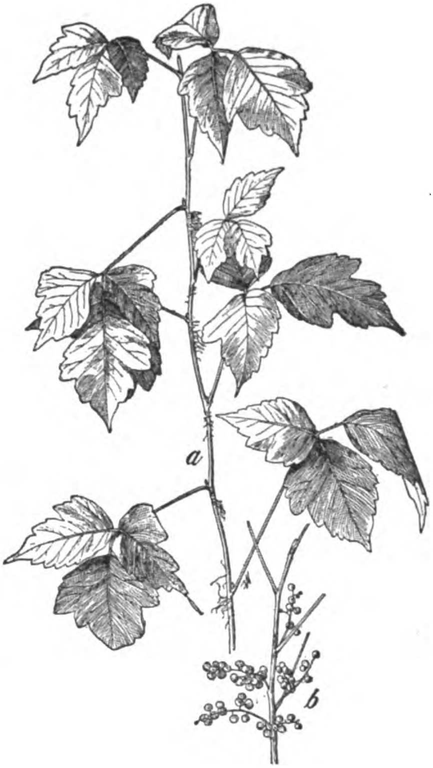

FIG. 13.—Poison ivy (*Rhus radicans*): *a*, spray showing aerial rootlets and leaves; *b*, fruit—both one-fourth natural size.

Poisonous character.—Recent experiments made by Dr. Franz Pfaff, of the Harvard University Medical School, have shown that the poison is a nonvolatile oil. It is found in all parts of the plant, even in the wood after long drying. Like all oils, it is insoluble in water, and can not therefore be washed off the skin with water alone. It is readily removed by alcohol, and very easily destroyed, as Pfaff has shown, by an alcoholic solution of sugar of lead (lead acetate).

Effect of the poison.—Numerous experiments show conclusively that the oil produces precisely the same effect as does the plant itself. When a very minute amount is placed upon the skin, it is gradually absorbed in the course of a day or so, and within certain limits the effect is proportional to the time of contact. In an experiment performed by the writer, the oil was applied to four places on the left wrist, and these were carefully guarded to prevent spreading. At the end of an hour one of the spots was thoroughly washed by successive applications of alcohol; in three hours the oil from a second was washed off in the same manner, and the others were cleansed three hours later. There was little or no effect on the first; that on the second was more marked, but did not equal that produced on the last two, which was about the same in each. The spots were within an inch of each other, but remained wholly distinct, a fact which very clearly shows that the affection is not spread by the blood. Subsequent applications of an alcoholic solution of sugar of lead gave speedy and permanent relief.

Remedies.—In practice it is not desirable to use strong alcohol, which is apt to be too irritating to a sensitive surface, but a weaker grade of from 50 to 75 per cent is recommended. To this the powdered sugar of lead is to be added until no more will easily dissolve. The milky fluid should then be well rubbed into the affected skin, and the operation repeated several times during the course of a few days. The itching is at once relieved and the further spread of the eruption is checked. The remedy has been tried in a large number of cases and has always proved successful. It must be remembered, however, that the lead solution is itself very poisonous if taken internally.

Restrictive and preventive measures.—It is highly desirable that legal measures be adopted compelling the destruction of these plants where they abound in cities and in places of popular resort. This can be managed without much danger from the poison, and is a matter of very general public interest. As has already been noted, many individuals are practically immune from the effects of poison ivy. Advantage should be taken of this fact to employ such individuals to remove these plants from the vicinity of dwellings and from playgrounds. Much of the work would be purely mechanical, consisting in rooting the plants up by main force. This is the most certain method; the use of concentrated sulphuric acid is attended with less danger, as the plants do not need to be touched. A half teaspoonful should be applied to the stem every two or three weeks in the springtime when the plant is growing most vigorously. Care should be taken to keep the acid away from the skin, as it is most highly corrosive. The brush should in no case be left upon the ground nor the wood used for fuel. In burning the refuse in the field, pains should be taken not to inhale the smoke nor to handle the wood any more than necessary.

The greatest care should be exercised in preventing workmen from transferring the oil from their clothes and hands to other individuals. To accomplish this object special suits should be worn, and the hands should be washed several times a day with the alcoholic sugar of lead solution described above. Bathing in hot water with strong soapsuds is recommended. The clothing must also be well washed, and it is always well to remember that towels may be a means of conveying the oil.

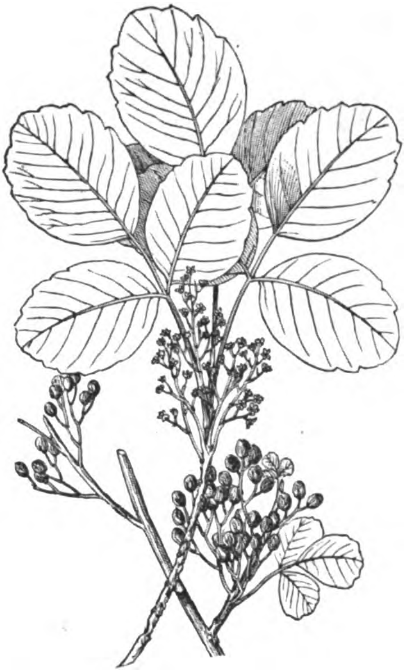

FIG. 14.—Poison oak (*Rhus diversiloba*), showing leaves, flowers, and fruit, one-third natural size.

POISON OAK.

Rhus diversiloba Torr. & Gr.

Other names: Poison ivy; yeara; California poison sumac. (Fig. 14.)

Description and where found.—The poison oak differs from the preceding species mainly in the character of its leaflets, which are somewhat thicker and smaller, more nearly elliptical, and less sharply lobed. Their similarity to the leaves of the Western oaks gives the plant its common name. The poison oak grows at low elevations in open woods, on bushy hillsides and ravines, and sometimes along fences, in Arizona and to the west of the Sierra Nevada and Cascade ranges in California, Oregon, and Washington. It does not, however, frequent the higher mountains.

Poisonous character and remedy.—This species produces about the same effect on the human skin as the poison ivy, and cases of poisoning are to be treated in the same way.

POISON SUMAC.

Rhus vernix L.

Other names: Swamp sumac; dogwood (Mass.); poison dogwood; poison elder (Ala.); poison ash (Vt.); poison tree; poison wood; poison swamp sumac; thunderwood (Ga., Va.). (Fig. 15.)

Description and where found.—A tree-like shrub 6 to 30 feet high, with long pinnate leaves having from 7 to 13 leaflets, without marginal teeth. The wood has a faint sulphurous odor, which, together with the leaf scars, which are very prominent, enables one to distinguish the plant from other shrubbery in winter. It grows in swamps and in damp woods from Florida to Canada and westward to Louisiana.

Poisonous character.—This also affects the skin in the same way as poison ivy, and cases require the same remedy.

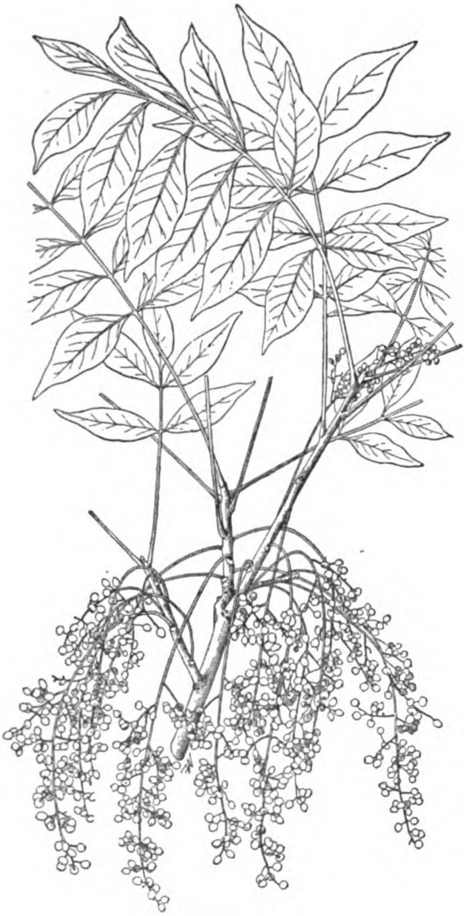

FIG. 15.—Poison sumac (*Rhus vernix*), showing leaves, fruit, and leaf-scars, one-fourth natural size.

RED BUCKEYE.

Aesculus pavia L.

Other names: Small buckeye; buckeye; horse-chestnut.

Description and where found.—A shrub 8 to 12 feet high, with opposite long-stemmed leaves, and numerous clusters of bright red flowers, which appear in March. The fruit is smooth, even when young; the seeds are mahogany-colored and are elegantly polished. The red buckeye is native in fertile valleys from Virginia to Florida, throughout the Gulf States to Louisiana, and in Arkansas. It is sparingly represented in Missouri, Tennessee, Kentucky, and West Virginia. It is cultivated to some extent in Pennsylvania.

Poisonous character.—The records of its poisonous action are mostly confined to its use as a means of procuring fish, but cattle are sometimes killed by eating the fruit. It was formerly, and perhaps is still, the practice to stir the bruised seeds or twigs into small ponds and gather the stupefied fish by hand as they rise to the surface. When thoroughly cooked these fish are quite wholesome.

Other species.—The common horse-chestnut (*Aesculus hippocastanum*) is poisonous. In England, however, it is fed to cattle after the removal of the poison by thorough washing with alkali. Cases of poisoning by this and the next species have arisen from overdoses in medicine. The Ohio buckeye (*Aesculus glabra*) is regarded as intermediate between the above species in its poisonous qualities. The fruit of the California buckeye (*Aesculus californica*) is sometimes made into soup and bread by the Round Valley Indians, after removing the poison by roasting and leaching.

WATER HEMLOCK.

Cicuta maculata L.

Other names: American water hemlock; wild hemlock; spotted hemlock; spotted parsley; snakeweed; beaver poison; musquash root; muskrat weed; cowbane; spotted cowbane; children's bane; death of man. (Fig. 16.)

Description and where found.—A smooth, erect, perennial, 3 to 8 feet high, with a rigid, hollow stem, numerous branches, finely dissected leaves, white flowers, and a cluster of spindle-shaped roots, which vary in length from 1½ to 3 inches, and are very characteristic of the plant. It grows commonly in swamps and damp soil, throughout the Atlantic States, westward to Louisiana, Iowa, and Minnesota; much less commonly northwestward through Nebraska to the Rocky Mountains, and in New Mexico.

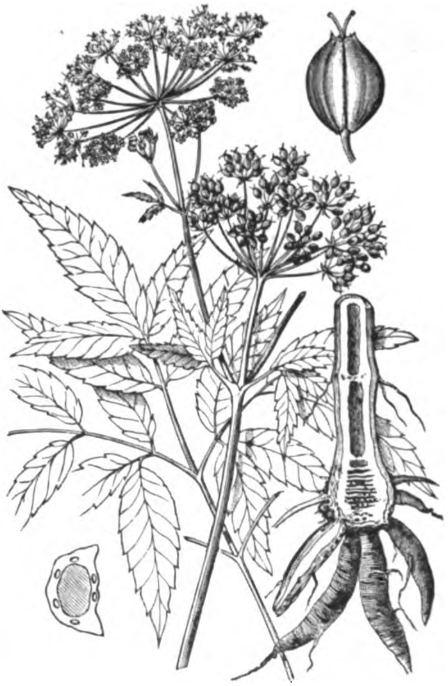

FIG. 16.—Water hemlock (*Cicuta maculata*), showing section of spindle-shaped root and lower stem, the leaves, flowers, and fruit one-half natural size; also fruit and cross section of seed, enlarged five times.

Poisonous property.—This is one of the most poisonous native plants in the United States, being rapidly fatal to both man and animals. The roots are especially dangerous, because the taste, being aromatic and to some people suggesting that of horse-radish, parsnips, artichokes, or sweet cicely, is apt to lead children to eat them when they are found forced out of the soil by washing, freezing, or other causes in early spring. Cattle sometimes eat the tubers, and in marshes they are poisoned by drinking water contaminated by the juice of roots which have been crushed by being trampled upon. No estimate can be made of the amount of damage done to live stock, but it is very considerable. The human victims average several per annum. In the State of New Jersey alone, as mentioned in the introduction, two quadruple cases were reported during the spring of 1896, which resulted in the death of two individuals.

Symptoms.—The prominent symptoms are vomiting, colicky pains, staggering, unconsciousness, and frightful convulsions, ending in death.

OREGON WATER HEMLOCK.

Cicuta vagans Greene.

Other names: Water hemlock; cicuta. (Fig. 17.)

Description and where found.—A smooth perennial, with erect or straggling glaucous stems 3 to 6 feet high, compound leaves, which spring directly from the ground, white flowers, blooming in July and August, and a fleshy root, which has a muskrat-like odor, and which consists of two very distinct and characteristic parts. The more conspicuous of these is the vertical rootstock, which is from 1 to 6 inches long by 1 or 2 thick, and is curiously divided into numerous chambers by horizontal partitions. This rootstock furnishes the bulk of the poison. The other portion of the root consists of solid, fleshy fibers, which run along on or just under the surface of the soil, and send off numerous rootlets from beneath. The rootstock rots or dwindles away almost entirely before the seeds mature, but fresh ones are formed from it for the next season's growth. The plant grows in wet or marshy places, and ranges from British Columbia and Idaho southward to northeastern California, and perhaps to the southern Sierra Nevada.

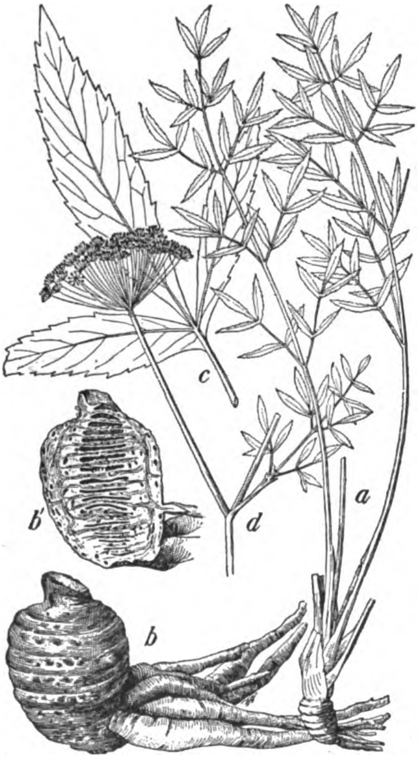

Fig. 17.—Oregon water hemlock (*Cicuta vagans*): *a*, plant with leaves, one-sixth natural size; *b*, rootstock and horizontal roots; *b'*, section of rootstock, half size; *c*, terminal leaflets, one-sixth natural size; *d*, flowering spray, full size.

Cases of poisoning.—Cases of cattle poisoning have been reported from Victoria, British Columbia; Colby, Wash.; from various parts of Oregon, and from northern California. Prof. U. P. Hedrick, of Corvallis, Oreg., who has investigated cases of poisoning from this plant, believes that more than one hundred cattle are killed by it every year in Oregon. A piece of the winter rootstock the size of a walnut was found to be fatal to a cow. A piece the size of a marble is looked upon as dangerous to man. Human cases are not numerous, but a few have been reported in which individuals nibbled at the root through curiosity.

The Oregon water hemlock has often been mistaken for the preceding species, and also for *Cicuta virosa* L., but neither of these occur in the far Northwestern States. Some other plants that are mistaken for it are the so-called "wild celery" (*Oenanthe sarmentosa*), Oregon sweet cicely (*Glycosma ambigua*), and poison hemlock (*Conium maculatum*). These are all easily distinguished by the root, which in no case resembles the one here figured.

When these plants occupy large areas, the only safeguard for cattle is to keep them on other pastures, especially when they are hungry. The plants may be destroyed by hand pulling when they occur in small quantities near dwellings or playgrounds.

POISON HEMLOCK.

Conium maculatum L.

Other names: Hemlock; wild hemlock; spotted parsley; stinkweed; herb bennet; poison root; poison snakeweed; cashes; wodewhistle. (Fig. 18.)

Description and where found.—A smooth, purple-spotted, hollow-stemmed biennial, 2 to 7 feet high, with large parsley-like leaves and showy clusters of small white flowers, which appear in July and August. The seed is prominently ridged, and has on its inner surface a deep, narrow, longitudinal groove. The fresh leaves have an extremely nauseating taste, and when bruised emit a characteristic mouse-like odor. Poison hemlock is native to Europe and Asia, but has become naturalized in the United States, and is rather common on waysides and in waste places in New York, West Virginia, Pennsylvania, New Jersey, and Ohio, and not rare in the New England States and in Michigan. It is infrequent in Wisconsin, Illinois, Louisiana, and California, but in some localities in the latter State it has a very rank growth.

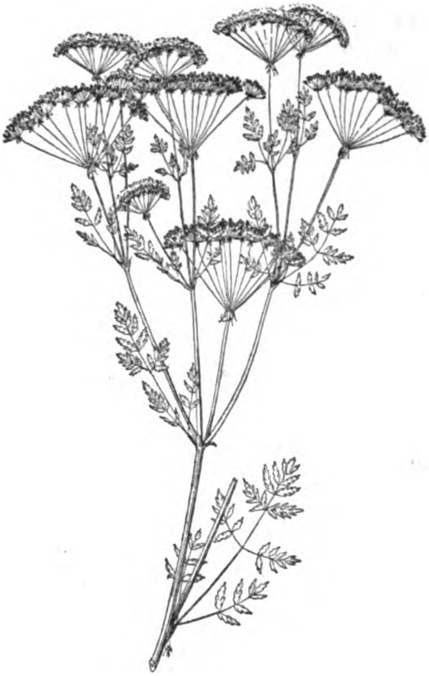

FIG. 18.—Poison hemlock (*Conium maculatum*), showing upper portion of plant, with flowers and seed, one-third natural size.

Character of the poison.—The characteristic poison of the hemlock is the well-known volatile alkaloid, conine, which is found in the seeds, and, especially at flowering time, in the leaves. The root is nearly harmless in March, April, and May, but is dangerous afterwards, especially during the first year of its growth. The poison hemlock is the most generally known poisonous plant historically, it being without much doubt the plant administered by the Greeks to Socrates and other state prisoners. Recent cases of poisoning have arisen accidentally from eating the seed for that of anise, the leaves for parsley, or the roots for parsnips; also from blowing whistles made from the hollow stems. It has recently been shown that some of the anise seed in both foreign and domestic markets is contaminated with hemlock seeds, but it is not known whether serious consequences have resulted therefrom.

Symptoms.—The symptoms in man are such as are due to a general and gradual weakening of muscular power. The power of sight is often lost, but the mind usually remains clear until death ensues, as it soon does from the gradual paralysis of the lungs. The poisoning differs from that of the water hemlock (*Cicuta maculata*) in the absence of convulsions. Many domestic animals have been killed by eating the plant, the prominent symptoms described for cows being loss of appetite, salivation, bloating, much bodily pain, loss of muscular power, and rapid, feeble pulse.

As this plant does not often occur in great quantity in the United States, it may usually be destroyed by hand pulling before maturity.

BROAD-LEAF LAUREL.

Kalmia latifolia L.

Other names: Laurel (north of Md.); ivy (south of Md.); mountain laurel; sheep laurel; poison laurel; wood laurel; small laurel; rose laurel; high laurel; American laurel; poison ivy; ivy bush; ivy wood; big ivy; calico bush; spoonwood; kalmia; wicky. (Fig. 19.)

Description and where found.—A fine shrub, usually 4 to 8, but sometimes 30 to 40 feet high. It has thick, flat, and shining leaves, showy clusters of peculiarly shaped, viscid, and mostly inodorous pink flowers, which appear in May and June, and a globular, viscid, dry, and inedible fruit. It grows abundantly on rocky hillsides, in cattle ranges, and on mountain slopes up to 3,000 or 4,000 feet, from Connecticut to eastern Ohio and along the Alleghenies to Georgia and Alabama; less abundantly in the New England and Southern States as far as Louisiana and Arkansas.

Ways of poisoning.—Scores of cattle and sheep are poisoned annually by eating the shrub. Access to it is generally obtained by breaking away from inclosures, or through neglect or accident when cattle or sheep are being driven past laurel thickets to upland pastures in early spring. Laurel leaves (commonly used for decorative purposes in winter), or the flowering branches, are often carelessly thrown into inclosures where animals are kept. The older cattle are not so frequently killed by it, but they are by no means immune. Horses and even goats have died from eating the leaves.

It is stated that chickens have been poisoned by eating the vomited matter from poisoned animals. Experiments show, however, that they are able to withstand considerable quantities of the pure poison when it is fed to them. In these experiments the chickens were killed with chloroform after dosing for a few days. The entrails were then cast aside, and the well-boiled and well-cleansed meat was fed to cats with nearly fatal results.

The honey derived from the nectar of the flower appears to be poisonous under some conditions. Cases of human poisoning occur indirectly in the ways indicated above; directly by overdoses, or improper use in domestic medicine, probably by the secret and criminal use of the leaves to increase the intoxicating effects of liquors, and, in children, by their eating the young shoots by mistake for the wintergreen (*Gaultheria procumbens*).

Symptoms.—The general symptoms in sheep may be taken as representative for those in cows and goats. They are as follows: Persistent nausea, with slight but long-continued vomiting and attempts to vomit, frothing at mouth, grating of teeth, irregular breathing, partial or complete loss of sight and feeling, dizziness, inability to stand, extreme drowsiness, stupor, and death. The irregularity of the respiration is most characteristic, being present throughout the main part of the attack. In addition to most of the above effects there is, in man, severe pain in the head, an increased tendency to perspire, and often a peculiar tingling sensation in the skin throughout the entire body. Vomiting is very copiously produced, and consequently the effects are generally less severe than in animals.

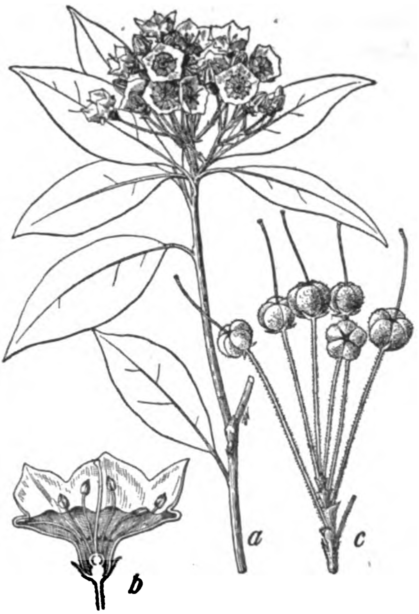

FIG. 19.—Broad-leaf laurel (*Kalmia latifolia*): *a*, flowering spray, one-third natural size; *b*, vertical section of flower showing peculiar attachment of stamens, natural size; *c*, fruiting capsules, natural size.

The broad-leaf laurel is typical in its effects of a half dozen or more native species of the heath family. They are all poisonous in the same way, because they all contain the same toxic or poisonous substance, known as andromedotoxin. Many fatalities among animals are recorded against the four species whose descriptions follow.

NARROW-LEAF LAUREL.

Kalmia angustifolia L.

Other names: Sheep laurel; lambkill; sheep poison; lamb laurel; dwarf sheep laurel; small laurel; low laurel; dwarf laurel; wicky.

Description and where found.—Like the preceding, but smaller, only 2 to 4 feet high, with smaller, thinner, and narrower leaves, and smaller flowers, clustered, not at the extreme end of the stem, but at the base of the fresh shoots. It is abundant at low altitudes in both dry and wet soils from Maine to New Jersey; less abundant westward throughout the Great Lakes region and southward to Tennessee and South Carolina.

GREAT LAUREL.

Rhododendron maximum L.

Other names: Laurel (south of Pa.); rosebay; mountain laurel; rhododendron; American rosebay; big laurel (Pa.); big-leaf laurel (Pa.); horse laurel (Pa.); deer tongue; cow plant (Vt.); spoon hutch (N. H.).

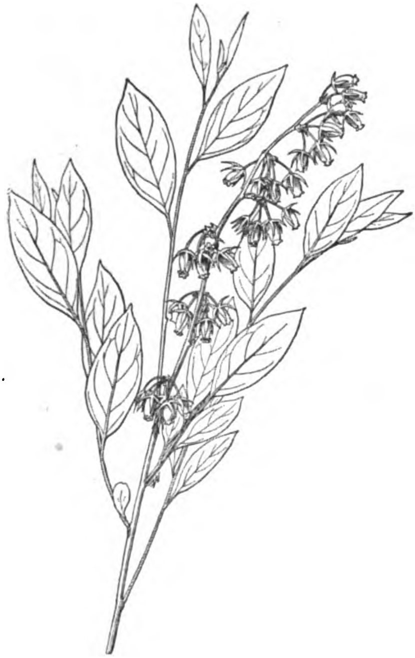

FIG. 20.—Staggerbush (*Pieris mariana*), showing flowering branch, one-third natural size.

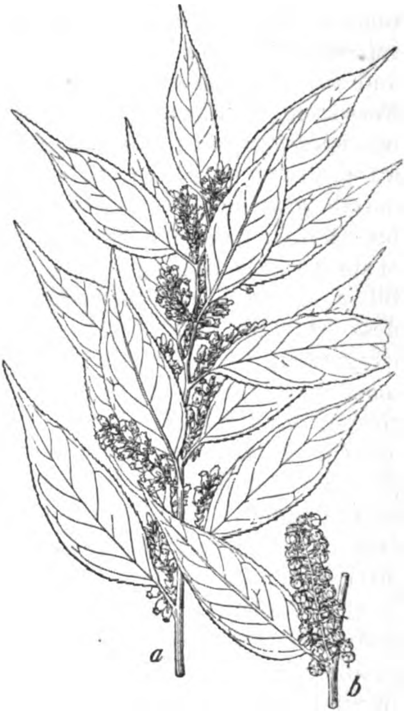

FIG. 21.—Branch ivy (*Leucothöe catesbaei*): *a*, flowering branch; *b*, fruiting capsules—both one-third natural size.

Description and where found.—A large evergreen bush or small tree, 10 to 20 or 30 feet high, with thick leaves, 4 to 10 inches long, and splendid clusters of large, inodorous, pale pink, or nearly white flowers, blossoming in July. A commonly cultivated ornamental tree, native to the Allegheny Mountains, but extending northward in isolated patches to Connecticut and New Hampshire.

STAGGERBUSH.

Pieris mariana (L.) Benth. & Hook.

Other name: Kill lamb. (Fig. 20.)

Description and where found.—A weak-limbed deciduous shrub, 2 to 4 feet high, with thick conspicuously veined leaves and showy clusters of tubular white flowers. It is frequent in low, damp soils near the coast from Connecticut to Florida.

BRANCH IVY.

Leucothöe catesbaei (Walt.) A. Gray.

Other names: Hemlock; calf kill; leucothöe; dog laurel. (Fig. 21.)

Description and where found.—An evergreen shrub, 2 to 4 feet high, with thick, tapering, sharply saw-edged leaves and numerous clusters of small, white, tubular, ill-smelling flowers, which appear in April or May. It grows abundantly, often forming dense thickets along stream banks in the Allegheny Mountains from West Virginia to northern Georgia.

JIMSON WEED.

Datura stramonium L.

Other names: Jamestown weed; common stramonium; thorn apple; apple of Peru; devil's apple; mad apple; stinkwort; stinkweed (W. Va.); Jamestown lily (N.C.); white man's plant (by Indians). (Fig. 22.)

Description and where found.—The jimson weeds are rank ill-smelling plants, with large funnel-shaped flowers and prickly four-valved seed pods. They are mostly weeds which have been introduced into the United States from Europe and tropical America. The present species is a stout, smooth, bushy annual 2 to 5 feet high, with a coarse green stem, large flaccid leaves, and white, heavy-scented flowers 2 to 4 inches long. The flowers appear from May to September, and the fruit ripens from August to November, according to latitude. The seeds are numerous and about the size of a grain of buckwheat. When fresh they are ill-scented and nauseating, but later they are not so disagreeable. The nectar is sweet, but a little nauseating. The jimson weed is native to Europe and Asia, but is now commonly introduced in waste grounds about dwellings in all of the States east of Iowa and Louisiana with, perhaps, the exception of Minnesota. It is common in eastern Kansas and Nebraska, and in some parts of Colorado, and has probably obtained some foothold in all of the Western States.

The purple-stemmed jimson weed (*Datura tatula*) is a somewhat taller plant, with purplish flowers and stems, but otherwise practically identical with the preceding, both in botanical and toxic characters. It is more abundant toward the South and West than the other.

Ways of poisoning.—Cases of poisoning arise in adults from excessive use as a stimulant or as a medicine. Children are sometimes tempted to eat the fruit if they are permitted to play where the weed is to be found. Several cases of this kind were reported to this Department during the fall of 1897. At Alpena, Mich., five children were badly poisoned in August by eating the seeds of the purple-flowered species, which was cultivated in a garden as a curiosity under the fanciful trade name of "Night-blooming Cactus." Several other cases where children have been poisoned by this plant have been reported. Children are also poisoned by sucking the flower or playing with it in the mouth. The fresh green leaves and also the root have occasionally been cooked by mistake for other wild edible plants. One or two instances are recorded in which cattle have been poisoned by eating the leaves of young plants which were present in grass hay.

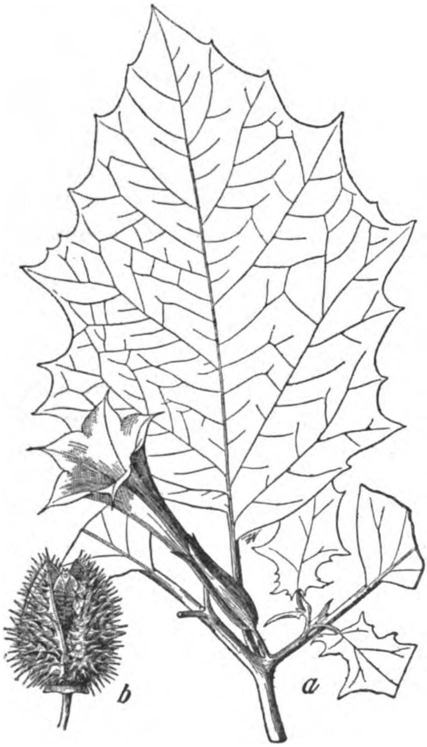

FIG. 22.—Jimson weed (*Datura stramonium*): *a*, flowering spray; *b*, fruiting capsule—both one-third natural size.

Symptoms.—The symptoms of the poisoning are headache, vertigo, nausea, extreme thirst, dry, burning skin, and general nervous confusion, with dilated pupils, loss of sight and of voluntary motion, and sometimes mania, convulsions, and death.

The jimson weeds should be removed from vacant lots by mowing the plants while in flower or by cultivating the soil.

BLACK NIGHTSHADE.

Solanum nigrum L.

Other names: Common nightshade; nightshade; deadly nightshade; garden nightshade. (Fig. 23.)

Description and where found.—The black nightshade is a smooth annual, 1 to 2 feet high, with rough, angular, widely branching stems; ovate leaves, 2 to 4 inches long, with wavy margins; drooping clusters of small white flowers, and black, globose, juicy berries, which ripen from July to October. It is a common introduced weed in rich shaded grounds and fields east of South Dakota and Arkansas, and in damp places westward to the Pacific Ocean.

Poisonous properties.—The amount of poison present in any part of this plant varies with the conditions of growth. The more musky-odored plants are the most poisonous. In some the amount of alkaloid in the ripe fruit and leaves is so small that these parts may be, and are, consumed in considerable quantity without any ill consequences. Poisoning does sometimes follow, but it is not clear whether this is due to improper preparation or to careless selection of the parts used. The use of black nightshade for food is certainly not to be recommended. Cases of poisoning are recorded for calves, sheep, goats, and swine.

Symptoms.—The characteristic symptoms are about the same in man and animals. They are stupefaction, staggering, loss of speech, feeling and consciousness; cramps, and sometimes convulsions. The pupil of the eye is generally dilated. Death is directly due to a paralysis of the lungs, but fortunately few cases are fatal.

Nearly related to this plant is the spreading nightshade or "wild potato" (*Solanum triflorum* Nutt.), a native garden weed of the Great Plains region. It is a smooth, low annual, with widely branching stems, 7 to 9 lobed leaves, numerous clusters of small white flowers which are grouped in threes, and large green berries a half inch or more in diameter. These are not attractive to the eye, but have an agreeable odor and taste.

Complaints of the poisoning of cattle by this plant have been sent in to the Department from Nebraska, and experiments show that the berries are poisonous. No cases of human poisoning have been reported.

The plants of either of these species may easily be killed by cutting them down before the fruit matures.

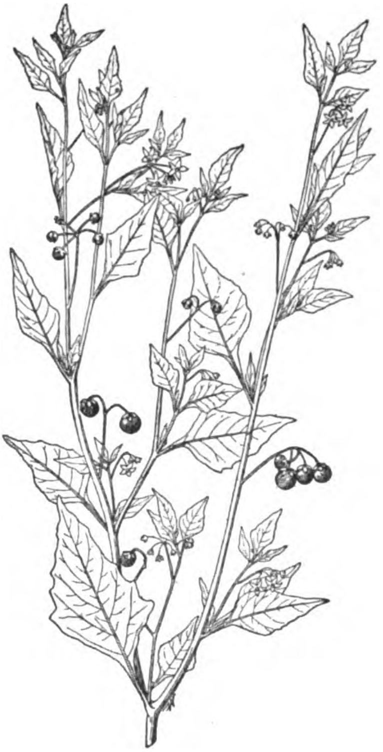

FIG. 23.—Black nightshade (*Solanum nigrum*), one-third natural size.

BITTERSWEET.

Solanum dulcamara L.

Other names: Woody nightshade; nightshade vine; staff vine; fever twig; tetonwort.

Description and where found.—A climbing, woody, introduced perennial 3 to 6 or 8 feet high, with thin leaves, the lowermost of which are ovate or heart-shaped, the upper more or less spear-shaped. The flowers are purple, the fruit red. It ripens from July to October and November. The plant thrives best and is common along brooks and ditches from Massachusetts to Ohio, less common elsewhere in damp ground from Maine to North Carolina and to Wisconsin and Missouri.

Poisonous property.—The berry, though its taste is not remarkably disagreeable, is somewhat poisonous, and it has been shown that an extract of the leaves is moderately so.

SNEEZEWEED.

Helenium autumnale L.

Other names: Sneezewort; autumn sneezewort; autumn sneezeweed; staggerweed (S. C.); swamp sunflower; false sunflower. (Fig. 24.)

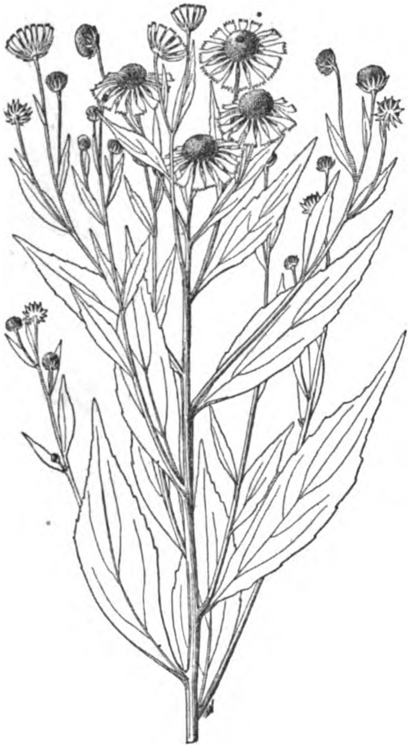

FIG. 24.—Sneezeweed (*Helenium autumnale*), one-third natural size.

Description and where found.—A smooth, angular, branching perennial, 1 to 3 feet high, with rather thick lance-shaped leaves, and a large number of showy yellow flowers which do not appear until autumn. It grows commonly in moist ground from Connecticut to Michigan and Illinois, and southward to the Gulf; less commonly northwestward from Louisiana to Oregon and Washington; also in Arizona. It has been found at an altitude of 6,000 feet in Nevada.

Poisonous character.—The whole plant, especially the flower, is bitter and more or less acrid and pungent. The powdered plant causes violent sneezing when inhaled, and it is therefore used in medicine to produce that effect. Sheep, cattle, and horses that are unfamiliar with the plant are often poisoned by it when driven to localities where it abounds. As a rule these animals avoid it, but it is claimed that they sometimes develop a taste for it and are killed by eating it in large quantity. The poison exists principally in the flowers. The young plants appear to be only very slightly dangerous; in the mature ones the amount of poison varies greatly even in the same field.

Symptoms.—The symptoms, as determined by experiments made in Mississippi upon calves, are an accelerated pulse, difficult breathing, staggering, and extreme sensitiveness to the touch. In fatal cases, death is preceded by spasms and convulsions.

Sneezeweed may be best kept in check by cultivating the ground or by mowing the plants down before the time of flowering.

274

U. S. DEPARTMENT OF AGRICULTURE.

FARMERS' BULLETIN No. 87.

Experiment Station Work,

VIII.

SOIL MOISTURE.
FERTILITY OF SOILS.
COVER CROPS FOR ORCHARDS.
CULTIVATING v. CROPPING ORCHARDS.
TRANSPLANTING TREES.
FECUNDITY OF SWINE.
FOOD VALUE OF EGGS.
STARCH FROM SWEET POTATOES.
THE TOAD AS A FRIEND OF THE FARMER.

PREPARED IN THE OFFICE OF EXPERIMENT STATIONS.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1899.

CONTENTS OF THE SERIES OF FARMERS' BULLETINS ON EXPERIMENT STATION WORK.

I. (Farmers' Bul. 56).—Good v. Poor Cows; Corn v. Wheat; Much v. Little Protein; Forage Crops for Pigs; Robertson Silage Mixture; Alfalfa; Proportion of Grain to Straw; Phosphates as Fertilizers; Harmful Effects of Muriate of Potash; Studies in Irrigation; Potato Scab; Barnyard Manure.

II. (Farmers' Bul. 65).—Common Crops for Forage; Stock Melons; Starch in Potatoes; Crimson Clover; Geese for Profit; Cross Pollination; A Germ Fertilizer; Lime as a Fertilizer; Are Ashes Economical? Mixing Fertilizers.

III. (Farmers' Bul. 69).—Flax Culture; Crimson Clover; Forcing Lettuce; Heating Greenhouses; Corn Smut; Millet Disease of Horses; Tuberculosis; Pasteurized Cream; Kitchen and Table Wastes; Use of Fertilizers.

IV. (Farmers' Bul. 73).—Pure Water; Loss of Soil Fertility; Availability of Fertilizers; Seed Selection; Jerusalem Artichokes; Kafir Corn; Thinning Fruit; Use of Low-grade Apples; Cooking Vegetables; Condimental Feeding Stuffs; Steer and Heifer Beef; Swells in Canned Vegetables.

V. (Farmers' Bul. 78).—Humus in Soils; Swamp, Marsh, or Muck Soils; Rape; Velvet Bean; Sunflowers; Winter Protection of Peach Trees; Subwatering in Greenhouses; Bacterial Diseases of Plants; Grape Juice and Sweet Cider.

VI. (Farmers' Bul. 79).—Fraud in Fertilizers; Sugar-beet Industry; Seeding Grass Land; Grafting Apple Trees; Forest Fires; American Clover Seed; Mushrooms as Food; Pigs in Stubble Fields; Ensiling Potatoes; Anthrax.

VII. (Farmers' Bul. 84).—Home-mixed Fertilizers; Forcing Asparagus in the Field; Field Selection of Seed; Potatoes as Food for Man; Corn Stover as a Feeding Stuff; Feeding Value of Sugar Beets; Salt-marsh Hay; Forage Crops for Pigs; Ground Grain for Chicks; Skim Milk for Young Chickens; By-products of the Dairy; Stripper Butter; Curd Test in Cheese Making; Gape Disease of Chickens.

LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
OFFICE OF EXPERIMENT STATIONS,
Washington, D. C., December 15, 1898.

SIR: The eighth number of Experiment Station Work, prepared under my direction, is transmitted herewith with the recommendation that it be published as a Farmers' Bulletin.

Respectfully,
A. C. TRUE,
Director.

Hon. JAMES WILSON,
Secretary of Agriculture.

CONTENTS.

Page.
Conserving and economizing the moisture of the soil 5
Influence of different systems of farming on the fertility of the soil 9
Cover crops for orchards 12
Cultivating *v.* cropping orchards 16
Application of water pressure to transplanted trees 21
The fecundity of swine 23
Food value of hens' eggs 24
The sweet potato as a starch producer 26
The toad as a friend of the farmer 28
Explanation of terms 31
  Terms used in discussing fertilizers 31
  Terms used in discussing foods and feeding stuffs 31
  Miscellaneous terms 32

ILLUSTRATIONS.

Page.
FIG. 1. Root system of a tree growing on a soil with hard subsoil 6
2. Root system of a tree growing on a soil with open subsoil 7
3. Cultivated and uncultivated apricot trees in a dry season 18
4. Effect of different systems of culture on the growth of apple trees 19
5. Apparatus for applying water pressure to transplanted trees 21
6. Effect of artificial root pressure on the opening of buds 22

EXPERIMENT STATION WORK—VIII.[1]

CONSERVING AND ECONOMIZING THE MOISTURE OF THE SOIL.

Next to temperature, moisture is probably the controlling factor in the growth of plants. The importance of an adequate supply of moisture is most strikingly demonstrated in regions of deficient rainfall where irrigation is necessary for the growth of crops (arid regions), but it is no less important in regions where the rainfall is usually considered sufficient for the needs of crops (humid regions). Not only must there be a sufficient supply of moisture, but it must be properly distributed throughout the growing season. It is well known that crops may be injured by drought in a season which shows a high total rainfall, because there is a deficiency of rain just at the stage when the plant needs it most.

Under all circumstances, therefore, it should be the farmer's aim to conserve the moisture in the soil—in the arid regions to reduce as much as possible the labor and expense of irrigation, and in humid regions to protect crops against droughts. Various means may be employed for the purpose of conserving and economizing the moisture supply of soils.

Subsoiling is one of the most important of these means. Several of the stations have made careful studies of the influence of subsoiling on soil moisture.[2] The Wisconsin Station describes this influence substantially as follows: Subsoiling (1) increases the storage capacity of the soil for moisture, and (2) increases the rate at which water will sink into the soil, but (3) decreases the rate at which it may be brought back to the surface. Subsoiling also increases the amount of moisture available to crops, since plants are capable of utilizing a larger proportion of the moisture present in loose and coarse-grained soils than of that in fine-grained and compact soils.

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[1] This is the eighth number of a subseries of brief popular bulletins compiled from the published reports of the agricultural experiment stations and kindred institutions in this and other countries. The chief object of these publications is to disseminate throughout the country information regarding experiments at the different experiment stations, and thus to acquaint our farmers in a general way with the progress of agricultural investigation on its practical side. The results herein reported should for the most part be regarded as tentative and suggestive rather than conclusive. Further experiments may modify them, and experience alone can show how far they will be useful in actual practice. The work of the stations must not be depended upon to produce "rules for farming." How to apply the results of experiments to his own conditions will ever remain the problem of the individual farmer.—A. C. TRUE, Director, Office of Experiment Stations.

[2] See also U. S. Dept. Agr., Farmers' Bul. 56 (Expt. Sta. Work—I, p. 20).

As regards the best method of subsoiling, a report of the Wisconsin Station states:

> Subsoiling to be most effective should be done in such a way as to leave the soil loose, much as the stubble plow leaves it. To accomplish this much will depend upon the character of the tool and more upon the condition of the soil when the work is done. If the soil is so wet as to be plastic when the plowing is done, then the effect of the subsoil plow will be to wedge the portions of the soil, which are heavily pressed into an even more compact and close texture than before, and thus develop a condition the opposite of that sought. To simply form a long groove or channel in the subsoil by wedging the dirt aside gives little aid in the direction sought.
>
> Such work, then, if done at all, should be done when the subsoil itself is dry enough, and this is most likely to occur in the fall after the crop of the season has withdrawn the moisture from it. Subsoiling late, too, leaves no time for the soil to lose its open texture before the rains to be stored reach it.

In humid regions, as a recent bulletin of the California Station points out, the soil as a rule is underlaid at a comparatively short distance below the surface by a subsoil which the roots of plants penetrate with difficulty and from which they can draw little nourishment. The roots, therefore, spread out near the surface, and the plants require frequent rains or irrigation to sustain life. A suspension of either rain or irrigation for ten days or two weeks under these conditions usually results in injury to the plant. Under such circumstances subsoiling encourages deep rooting, and thus enlarges the stock of water as well as plant food at the command of the plant. In many parts of the region of deficient rainfall, as in southern California, plants (especially fruit trees) are capable of withstanding months of drought. This is claimed to be due to the fact that "in the arid region, as a rule, subsoils in the eastern sense do not exist; the soil is readily penetrable to great depths." This difference in the root systems of plants in humid and arid regions is illustrated in the accompanying figures.

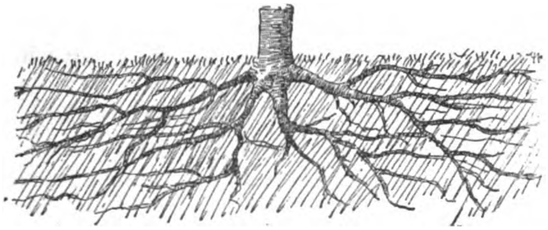

FIG. 1.—Root system of a tree growing on a soil with hard subsoil.

> A glance at the figures suffices to show that while a root system like fig. 1 will stand in absolute need of frequent rains or irrigation to sustain its vitality, such a one as fig. 2 may brave prolonged drought with impunity, being independent of surface conditions, and able to perform all its functions out of reach of stress from lack of moisture. It is equally clear that it is to the farmer's interest to favor to the utmost this deep penetration of the roots.

This can be done in humid regions, to some extent at least, by thorough preparation and tillage of the soil and (in case of fruit trees) by guarding against excessive surface fertilization. In arid regions frequent irrigation, it is claimed, encourages shallow rooting.

To prevent loss of water from the soil by evaporation it is necessary to check the rise of water by capillarity to the surface of the soil. As already noted, this is accomplished to some extent by subsoiling, but in order that the work partly accomplished by the subsoiling may be completed and continued, the surface of the soil must be kept covered with a mulch of loose, well-tilled soil by means of frequent tillage. Some experiments of the Kansas Station afford an illustration of the effectiveness of this means of conserving soil moisture.

One of the station fields which contained in round numbers 26 per cent of water in the first foot of soil, on July 7, 1898, had one portion plowed, another disk harrowed and a portion left untreated. The ensuing dry weather in the course of four weeks, notwithstanding several light rains, reduced the moisture of the untreated part to 15 per cent and that of the disked land to 18 per cent, the plowed ground retaining 21 per cent. The last two were in excellent condition for seeding, while the first would plow up lumpy and unsatisfactory.

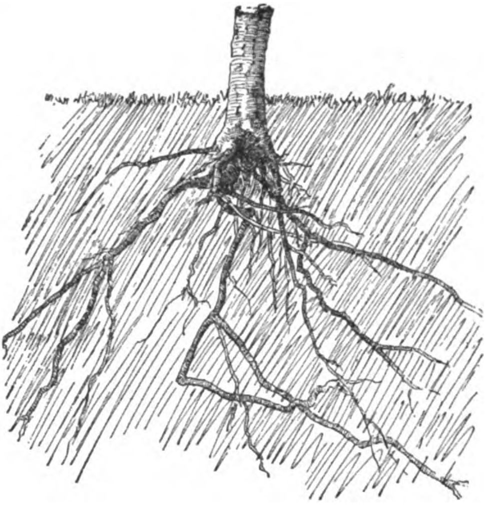
FIG. 2.—Root system of a tree growing on a soil with open subsoil.

In the experiments at the Kansas Station plowing proved as effective as any form of tillage tested. "If time does not permit plowing, the speedy work of the disk harrow compares favorably in efficiency. In either case, if rain sufficient to start the weeds follows, kill them with a harrow. This will at the same time break up any crust and preserve the soil mulch."

Whether the best results in preventing loss of moisture from the soil in humid regions will be obtained by subsoiling, shallow cultivation, or deep cultivation will depend very largely upon the character of the soil and subsoil. The Kansas Station found no essential difference in the moisture content at the different depths of soil that had been prepared in the spring by shallow plowing, by deep plowing, and by subsoiling. In experiments at the North Dakota Station on different methods of preparing soil and tillage for wheat the largest yield was obtained from land subsoiled 8 inches below a 6-inch furrow. A surface mulch of well-tilled soil 3 or 4 inches thick is usually considered sufficient to afford effective protection against evaporation in humid regions. In regions of deficient rainfall, however, twice this depth is considered necessary.

In humid regions there is danger of serious loss of nitrates in subjecting bare plowed land to the long-continued leaching action of abundant rains, as is done in summer fallowing and fall plowing; nevertheless, the Kansas Station has found that the plowing of stubble as soon as possible after the removal of the previous crop, with frequent stirring of the soil, as described above, "not only insures a perfect seed bed for wheat in respect to moisture, but the soil has time to settle to the firm condition so advantageous to wheat, and the bareness, warmth, and moisture are most favorable to the formation of nitrates from organic matter." In regions of deficient rainfall loss by leaching need not be feared. Under such conditions both summer fallowing and fall plowing may prove of great value in conserving moisture.

> Fall plowing wherever the land is not naturally adequately absorbent, and is not thereby rendered liable to washing away, is a very effectual mode of utilizing the winter's moisture to the utmost, so as to bring about the junction of the season's moisture with that of the previous season, which is generally considered as being a condition precedent for crop production in dry years. The same of course holds true of winter irrigation, the frequent omission of which in presence of a plentiful water supply at that season is a prolific cause of avoidable crop failures. Moistening the ground to a considerable depth by winter irrigation is a very effective mode of promoting deep rooting, and will thus stand in lieu of later irrigations, which, being more scant, tend to keep the roots near the surface.

Moisture escapes from soils bearing crops much more rapidly than from bare soils. This fact has been very clearly demonstrated by investigations by the Iowa, Kansas, Wisconsin, and other stations. These investigations show that sod land and soil bearing different crops always maintain less moisture than uncultivated soil of the same character. It is undoubtedly true that the injurious effect of weeds is due fully as much to the moisture which they withdraw from the soil as to the plant food which they consume. The poor growth of crops near hedgerows and woods is due largely to withdrawal from the soil of moisture required for the proper growth of the crops. It is a well-known fact that the culture of crops in orchards may prove injurious to fruit trees, especially in dry seasons. (See p. 18.) This is due mainly to the withdrawal by the crops of moisture needed by the trees. The danger from this source is especially great if the fruit trees are very shallow rooted. From the standpoint simply of conservation of moisture, therefore, the farmer should be careful to keep his land free from unnecessary vegetation during the summer, "but it must not be forgotten that by doing so he quickly depletes his land of vegetable matter, which requires systematic replacement if production is to continue normally," and, as explained above, he incurs danger of serious loss of nitrates by leaching and washing, especially in season of heavy rainfall.

It is thus seen that while there are many ways in which the moisture of the soil may be wasted or rendered useless to the plant, there are also many effective means of conserving and economizing this water which may be profitably employed. It only remains for the individual farmer to determine the method best suited to his needs and conditions.

INFLUENCE OF DIFFERENT SYSTEMS OF FARMING ON THE FERTILITY OF THE SOIL.

The amount of principal elements of fertility removed from the soil in products sold from the farm and the amount returned to it in the form of manure depend largely upon the system of farming practiced. It is well known that soils under continuous cultivation decline in fertility much more rapidly than those kept in grass. This is due not only to the constant removal of fertility in the crops harvested and sold from the farm, but also to the fact that under most systems of continuous culture the soil is left bare a large part of the time, and thus subjected to loss from leaching, washing, and oxidation. On the other hand, soils in grass are protected almost entirely from the latter losses. The roots of the plants bring up the fertilizing constituents from the lower layers of the soil and they accumulate at the surface of the soil in the decaying remains of the vegetation. Thus in case of grass lands, while there is no actual gain in total amount of fertilizing constituents in the soil, the plant food is made more available and accessible. These facts explain the apparent recuperation of soils which have been exhausted by continuous culture when kept under grass for a number of years. If leguminous plants are substituted for grasses, there may be an actual gain in fertility due to the nitrogen which these plants are capable of collecting from the air.

When the lands are grazed by sheep and cattle the soil fertility is drawn upon to the extent of the nitrogen, phosphoric acid, and potash required to build the blood, bone, and tissue of the animal body. This is considerable in the case of growing animals, but insignificant in case of animals which have made their growth (especially of bone) and are simply maintained or fattened on the pasture. If, however, concentrated feeds are used in addition to pasture, and the manure produced returned to the land, there is an actual gain in fertility of the land. It will thus be seen that exclusive grain farming or continuous culture of a single crop has a much greater tendency to impoverish the soil than stock raising or combined grain and stock raising. A comparison of the amount of plant food removed from the soil and the amount capable of being returned to it under different systems of husbandry has been made by the Minnesota Experiment Station. The systems taken into consideration were all-grain farming, mixed grain and general farming, mixed potato and general farming, stock farming, and dairy farming, examples being selected which represented the different systems. In each case the farm is considered to contain 160 acres.

In the example of all-grain farming selected no stock was kept and no fertilizers of any kind applied to the land, the small amount of fertilizing material which necessarily accumulated was disregarded, and the grain was all sold from the farm. The entire farm of 160 acres was under cultivation. The crops raised were 100 acres of wheat, 40 acres of barley, and 20 acres of oats, yielding 15, 40, and 50 bushels per acre, respectively. It is calculated that the fertility removed from such a farm in the grain and straw of one year's crops amounted to 2,460 pounds phosphoric acid, 4,020 pounds potash, and 5,600 pounds nitrogen. This does not include the fertility removed by the weeds, which often is very large, and the amount of nitrogen lost from the soil through leaching and the decomposition of humus.

The amount of nitrogen thus lost from a rich prairie soil recently brought under this system of farming is three or four times that removed in the crop. It was found from experiments conducted at this station that when a prairie soil is first brought under cultivation the humus oxidizes rapidly, but as the soil grows older the humus content diminishes and the oxidation of the humus goes on more slowly.

The system of mixed grain and general farming studied consisted of growing 40 acres of wheat, 20 of oats, 10 of barley, 7 of rye, 5 of corn, 3 of flax, and 1 each of peas, millet, and potatoes. The rest of the land was in meadow and pasture, and 10 cows, 4 head of young stock, 15 sheep, 8 hogs, 4 work horses, and 2 steers were kept. All the straw produced was used as feed and bedding for the stock. The yields in this case were higher than under all-grain farming, because the land was kept in better condition. All the wheat, rye, and flax, and one-half of the oats and barley, and 50 bushels of potatoes were sold from the farm. The animal products sold were 2 steers, 10 sheep, 8 hogs, and 1,500 pounds of butter. The remaining oats, barley, and potatoes, and the corn, peas, and millet, besides 20 tons each of timothy and clover, were consumed on the farm, and 80 per cent of these food materials were returned to the soil in the form of manure. The fertility returned to the farm in manure from the food purchased, such as bran, screenings, and meal of various kinds, was taken into consideration in every case. A comparison of the total amount of fertility removed from the farm and the amount returned to it shows an approximate loss from the soil of 1,003 pounds phosphoric acid, 1,047 pounds potash, and 2,594 pounds nitrogen. The fixation of the free nitrogen of the air by clover and peas was not taken into account in these figures, but "it is safe to calculate that there has been a gain of 1,500 pounds of nitrogen from this source." When allowance was made for the nitrogen thus obtained there was an annual loss from this farm of about 1,000 pounds each of phosphoric acid, potash, and nitrogen. There was therefore a loss of about two-fifths as much phosphoric acid, one-fourth as much potash, and one-sixth as much nitrogen as in all-grain farming. With good cultivation and management it is believed that the reserve fertility of a good soil will withstand the above losses for a number of years.

The system of mixed potato and general farming studied differed from the foregoing system in that about 40 acres of grain were replaced by potatoes and that less grain was sold and less mill products purchased. The stock kept consisted of 7 cows, 4 head of young stock, 4 horses, 2 steers, 12 sheep, and 9 hogs. Besides, 40 acres of grain were grown, of which 15 were sold. The rest of the farm was mainly in meadow and pasture. The products sold from the farm were 6,000 bushels of potatoes, 1,000 pounds of butter, 8 hogs, 2 steers and young stock, 10 sheep, and the yields of 10 acres of oats and 5 of barley. Fifteen tons each of clover and timothy, 40 tons of straw, 150 bushels of potatoes, and the yields of 10 acres each of oats and barley, 5 acres of corn, and 1 acre each of millet and peas grown on the soil were consumed on the farm. Here, as in the previous example, 80 per cent of the food consumed was returned to the soil. The approximate loss from the soil under the system amounted to 991 pounds of phosphoric acid, 2,435 pounds of potash, and 2,463 pounds of nitrogen. Deducting the nitrogen accumulated in the soil through the agency of the clover crop, the net loss of nitrogen is less than 1,000 pounds. Another advantage of growing clover, as pointed out, is that a deep-feeding crop, like clover, will bring up the fertility from the lower layers of the soil and concentrate it in the surface soil. This is especially desirable in potato farming which makes a heavy draft on the fertility of the soil, especially the potash.

In the example of stock farming selected for study, 25 acres were sown to oats, 20 to barley, 10 to corn, 5 to peas, and 1 acre each to potatoes and millet. The remainder of the farm was in meadow and pasture. The stock kept in this case comprised 10 beef cattle, and 10 dairy cows, 10 horses, 5 steers, 10 head of young stock, 30 sheep, and 20 hogs. Five steers of 1,000 pounds each, 5 head of young stock, 5 horses, 10 hogs of 250 pounds each, and 1,500 pounds of butter were sold from the farm. All the crops grown, including 40 tons of timothy and 30 tons of clover, were consumed on the farm. Eighteen tons of food material and 5 cords of wood were purchased and consumed, besides the crops produced. Under these conditions there was approximately a gain of 35 pounds of phosphoric acid, and a loss of 50 pounds of potash, and 898 pounds of nitrogen. The loss of nitrogen was more than balanced by the gain due to the clover crop, so that on the whole there was practically no loss of fertility from the farm.

In the example given of a dairy farm, 30 cows, 5 head of young stock, 4 horses, and 20 pigs constituted the stock kept on the farm. The crops raised were 10 acres of wheat, 20 of oats, 10 of corn, 7 of rye, 5 of oats for hay, 2 acres each of roots and peas, 1 each of millet and potatoes; 25 tons of both clover and timothy were produced, and the remainder of the farm was mainly in pasture. Sixteen pigs of 250 pounds each and 4 head of young stock, 5,000 pounds of butter, and all the wheat and rye produced were sold from the farm, while the rest of the products were consumed as feed and 80 per cent returned to the soil as fertilizer. Ten tons of feed and 5 cords of wood were purchased and consumed in addition to what was produced on the farm. The figures given for dairy farming show a gain of 76 pounds of phosphoric acid and a loss of 85 pounds potash, and 809 pounds nitrogen. The loss of nitrogen, however, is again more than offset by the gain through the clover crop, so that there is practically no loss of fertility in dairy farming under proper management, but rather a constant gain.

The loss of fertility under the different systems of farming is given in the following table. The gain of nitrogen through clover culture is disregarded in these figures:

Approximate loss of fertility from 160 acres of land under different systems of farming.

System of farming.	Phosphoric acid.	Potash.	Nitrogen.	Mineral matter.
	Pounds.	*Pounds.*	*Pounds.*	*Pounds.*
All grain	2,460	4,020	5,600	18,420
Mixed grain and general	1,003	1,047	2,594	5,419
Mixed potato and general	991	2,435	2,363	6,070
Stock	[a] 35	59	898	3,243
Dairy	[a] 76	85	809	1,818

[a] Gain.

These figures given * * * are not intended to convey the idea that an equivalent amount of each element must always be returned to the soil, but they are intended to show where the heaviest drafts fall on the soil with each system of farming.

In making comparisons, the variations which are liable to occur should be kept in mind. In exclusive grain farming the loss of the nitrogen is greater than given because when the soil is continually uncovered by the cultivation of plowed crops some of the nitrogen is lost by drainage and by the decomposition of the humus. When clover is grown in the other systems of farming, the loss of the nitrogen is less than stated.

The annual loss of phosphoric acid with exclusive grain farming is nearly 2,500 pounds per 160 acres. With mixed grain or potato farming this loss is reduced to about 1,000 pounds.

With stock farming, when all of the crops are fed to the stock on the farm and a small amount of milled products is purchased, there is practically no loss of phosphoric acid and potash, except in the handling of the manure. When the manure is well cared for, the losses of these elements are both less than stated.

In the case of dairy farming or stock farming, when all of the skim milk is fed on the farm and a part of the grain is exchanged for more concentrated milled products, there is no loss, but on the other hand a constant gain of fertility to the soil.

COVER CROPS FOR ORCHARDS

An orchard cover crop is a crop grown in the fall and winter to protect the soil and trees of orchards, and at the same time to improve the soil. Unlike crops grown throughout the season, cover crops, as a rule, do not injure the trees by drying out the soil, for in many places heavy fall rains are the rule, and even where the weather during the fall is normally dry the injury is less than in summer, since plants evaporate less water from their leaves in the cooler weather and shorter days of fall than in the longer and hotter days of summer. Cover crops not only do not, as a rule, dry out the soil injuriously, but they also add directly to the moisture-holding capacity of the soil by the humus formed in their decay, and they hold much of the snow until it melts and is absorbed by the soil.

Another reason why cover crops are rarely as injurious as crops grown throughout the entire season and are often beneficial is that their growth is made after the trees have stopped growing and are maturing their wood for winter. The Michigan Station has shown that the majority of trees in that locality complete their growth by July. Of course, the conditions observed in Michigan do not occur in all climates or seasons, but they show unmistakably the tendency of trees to make their greatest growth early in the season. Trees therefore require much less moisture in the latter part of the season than they do in the early part. Indeed, in moist localities it is often thought to be a distinct advantage to stop cultivation by midsummer and grow some secondary crop which will check the growth of the trees and cause them to mature before winter. The Washington Station, in studying the unusually severe freeze occurring in the fall of 1896, found that in most instances late summer cultivation had an injurious effect similar to late irrigation. "Wherever cultivation or irrigation had been kept up late in the season and the ground was moist and the trees in an active growing condition, there the frost did most damage."

Among other benefits to be derived from cover crops is the checking of washing and leaching of the soil. Light soils are often gullied by heavy rains in the fall just as in summer, and some crop to bind such soils is beneficial. In the case of soil leaching and the consequent loss of plant food, especially nitrates, a crop is more valuable in the fall and early winter than earlier in the season, for in spring and summer the tree roots are in condition to take up much of the plant food as it becomes available; but from the time their leaves fall until the soil is frozen the plant food which would otherwise escape in the drainage water or be washed down beyond the reach of plants can be saved only by secondary crops, which grow until stopped by the severe weather of winter. Even in cases where the leaching of soils is not excessive a deep-rooting cover crop brings up plant food from the subsoil and leaves it near the surface to be used later by the trees.

Besides preventing in part the loss of fertilizing elements from the soil, cover crops may serve as a direct fertilizer. For this purpose the well-known ability of leguminous plants to take nitrogen from the air and store it, so that it can be used later by other plants, is made use of. The use of such crops in ordinary farm rotations is well known. That they may be equally useful in case of orchard fruits is shown by tests at the New Jersey Station. Crimson clover was sown in the peach orchard on sandy soil in the latter part of July and the crop was plowed under in the latter part of the following May. The cover crop retarded the growth of the trees somewhat in the spring, but after it was plowed under they gained rapidly, and both wood growth and fruitage were more satisfactory than in the remainder of the orchard, which was fertilized with nitrate of soda. The use of leguminous crops, however, is not to be recommended in all cases. It often happens that soils become too rich in nitrogenous fertilizers, and the trees, therefore, grow too vigorously, do not mature their wood well, and are unfruitful. In such cases leguminous crops should not be used.

Cover crops may also improve the physical condition of the soil. In this connection the relation of humus to the water-holding capacity of the soil has been already noted. Humus is also beneficial in changing the character of very heavy soils, making them more porous and lessening their tendency to puddle in wet weather. Cover crops which live through the winter are of use in drying out heavy wet soils in spring so as to allow of cultivation.

Cover crops may also be advantageous in protecting the trees and fruit. The Delaware Station reports lessened injury to fruit blown from the tree where the soil was covered with a crop of crimson clover. In the extreme North cover crops are thought to be of advantage in preventing deep freezing and alternate freezing and thawing of the soil and the consequent injury to the roots of trees. At the Delaware Station ground covered with crimson clover is reported as unfrozen when the temperature of the air was 14° F. In some cases a cover may be injurious rather than beneficial to trees and fruit through the protection afforded to insects, mice, etc.

To secure the best results with a cover crop that lives over winter, it should be plowed under early in the spring while it is still succulent enough to decay rapidly. A crop plowed under late in the spring after it has become more or less woody will decay slowly, keep the soil too loose, and thereby serve to dry it out rather than retain its moisture. In many regions the crop may also do injury by the evaporation of moisture from its leaves if allowed to grow too late in spring.

The kind of crop that should be grown for winter cover must be determined by local conditions. In general the best crop is one that can be sown after tree growth stops, continues growth late in the fall, makes a close, thick cover, lives over winter, and furnishes considerable green manure. Nevertheless some crops which winterkill furnish considerable winter protection and serve fairly well the purpose of a green manure. Red clover and alfalfa, though good green-manure crops in general farming, are not suitable as a rule for growth in orchards, since they do not start well late in summer and require too much time to reach their full development. At the Canada Experimental Farms alfalfa and red clover proved inferior to mammoth clover. A mixture of alfalfa and mammoth clover, however, made a good cover; the mammoth clover covering the ground thickly below the taller and more slender alfalfa. Mammoth clover was considered the most satisfactory cover crop for Canada. It germinated promptly, soon took possession of the ground, and began growth early in the following spring. At the New York State Station mammoth clover formed a dense covering and remained alive over winter, comparing favorably with winter vetch and winter rye. A mixture of the latter formed a perfect mat of vegetation and remained green over winter. At the New York Cornell Station the European vetch sown early in summer, though starting slowly, made a thick cover by the middle of September. It remained green and continued growing for some time after frost, the vines standing 2 feet high at the beginning of winter. On the approach of hard-freezing weather it fell, forming an even, carpetlike cover, and by spring the plants were decayed so they could easily be plowed under. The seed must not be sown too early for best results with summer cultivation, but the plant is, nevertheless, considered one of the best for New York. It is recommended to sow the seed the last of June or first of July or, if in very good soil, as late as the last of July. Soja beans and cowpeas have been successfuly grown in peach orchards in Connecticut. In Canada they are reported to have grown rapidly, but were killed by the first frost and did not make as good a cover as rye, buckwheat, or field peas. Cowpeas, and perhaps velvet beans[1] also, may prove valuable in the Southern States, but are not so well suited to the North. Both the New York stations report cowpeas as making a good growth, but the seed must not be sown too early to allow of the best cultivation. The plants are killed by the first frost, lose their leaves, and afford little winter protection. Field beans, while better than no cover, are open to the same objections as cowpeas. Field peas are often grown as a cover crop. At the New York Cornell Station field peas sown in the middle of August produced vines from 2 to 3 feet long and remained green after frost, making a good mulch. When sown as late as the middle of September they did not make a satisfactory cover. At the New York State Station Canada peas and buckwheat and blue peas and buckwheat gave satisfactory results, both mixtures making a good growth and the peas remaining green until winter. The growth of the Canada peas and buckwheat was so great as to interfere with the gathering of winter apples. Field peas are considered among the best crops for winter cover at the Nebraska Station, though most crops make a rather small growth in the dry falls of that region. Crimson clover[2] is considered an ideal cover crop wherever it withstands the winter, though it does not thrive on hard, poorly tilled soil as well as many other crops. It is reported by the New Jersey Station as being hardy throughout the State and considered much more economical than city manure as a nitrogenous fertilizer. It may be sown there from the middle of July to the middle of September. According to the Delaware Station, it is grown largely in the peach orchards of that State. It sends its roots to a depth of 4 feet even in hard soil, flourishes on poorer soil than red clover, and makes its growth during the fall, winter, and spring, growing when wheat and even rye seem dormant. In spring the sod is plowed in such a way as to leave many of the clover heads above the soil, to ripen and reseed the orchard. On poor soil cowpeas are sometimes grown during summer, and are followed by crimson clover sown in the pea vine in August. This practice is also recommended by the Virginia Station. Crimson clover has not proved entirely hardy at the Rhode Island, Michigan, New York State, and New Hampshire stations and at the Canada Experimental Farms, and was not satisfactory at the Nebraska Station on account of dry weather in the fall. In the locality of the New York Cornell Station crimson clover winterkills if sown too late. About the middle of July or first of August is recommended as the best time to sow it. If sown earlier, it matures and dies before winter. Failures with crimson clover are frequent, but no more so than with red or mammoth clover sown at the same time.

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[1] U. S. Dept. Agr., Farmers' Bul. 78 (Expt. Sta. Work—V), pp. 12–14.

[2] U. S. Dept. Agr., Farmers' Bul. 69 (Expt. Sta. Work—III), pp. 8–10.

Where a nitrogenous fertilizer is not desired, rye is a good cover crop. It is also useful on very light sandy soils, and on very hard lumpy soils where other crops are not easily grown. A few years' growth of rye may improve such soils sufficiently to permit of the use of other crops. Turnips have been recommended for use on hard dry land, where other crops do not start readily. Sown late in July, they are said to make a good cover in the locality of New York Cornell Station. Rape[1] may also serve a useful purpose as a cover crop. At the New York State Station dwarf Essex rape made a very rank growth, sufficient to interfere with gathering winter fruit. It seemed to furnish hiding places for mice, which girdled the trees badly. This, however, may occasionally be true of any heavy cover. Corn sown thickly one and one-half to two months before frost makes a good winter cover, though killed quickly by cold weather. Buckwheat is also good for the same purpose if sown so as to reach its full height but not to produce seed before winter. Among other plants of more or less value as cover crops, oats, wheat, barley, millet, and spurry are sometimes recommended.

CULTIVATING v. CROPPING ORCHARDS.

Whether orchards shall be cropped or given clean cultivation, how cultivation shall be done, whether it shall be continued throughout the season, and similar problems depend very largely on local conditions of soil, climate, and the like. It is evident, therefore, that no definite rules can be given for the cultivation of orchards in all localities. The principles underlying successful culture, however, are the same everywhere, and therefore a knowledge of them will aid in deciding local questions.

Various experiment stations have conducted experiments to find out what methods give best results and why they do so. At the New York

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[1] U. S. Dept. Agr., Farmers' Bul. 78 (Expt. Sta. Work—V), pp. 9-12.

Cornell Station it was found that the roots of trees only 5 or 6 years old have a greater spread than the tops. For instance, the roots of an apple tree in rich, cultivated soil extended 8 feet from the trunk, while the entire top was not over 8 feet across. Another apple tree in sod, with a top only 6 feet across, had roots 10 feet long. A pear tree in poor soil had roots 21 feet long, while its entire top measured only 7 feet across. The roots of an apple tree which had stood in sod since planting were just beneath the surface of the soil, while the roots of those in cultivated soil were nowhere less than 8 inches from the surface. These facts show that if orchards are to be cultivated at all they must be cultivated from the first, since otherwise the roots grow so near the surface as to be injured by plowing and cultivation. They also show that to get the full benefit of cultivation all the space between the trees must be cultivated.

At the Nebraska Station a study was made of the effect of cultivation on the growth of apple trees, the size of fruit, and the water content of the soil. A small orchard was divided into three parts, one of which was cultivated regularly and the other two left in grass and weeds, one of the latter being mowed and the other pastured by hogs. The report says: "Trees in cultivated ground suffered noticeably less from the drought and hot winds of summer than those in sod ground. The foliage was darker and more vigorous in appearance, and there was no yellowing and dropping of the leaves nor wilting during hot windy days, both of which occurred with uncultivated trees. Apples from cultivated land averaged nearly 14 per cent larger in weight than those from pasture land and over 17 per cent larger than those from mowed land." The average percentages of moisture in the first 20 inches of the soil in the different portions of the orchard in the latter part of October were: Mowed portion, 14; pasture portion, 14.7; portion cultivated until August 1, 17, and portion cultivated the entire season, 20.4. The next season the results were practically the same. The average percentages of moisture in the first 24 inches of soil in the last of August were: Pasture part, 14.6; mowed, 14.6; cultivated, 21.2. The differences in moisture were greater at a depth of 6 inches than the average differences given above, and were noticeable even at a depth of 20 inches. Observations on some grass land near the orchard showed that alfalfa only 2 years old took the moisture from the soil as completely as an old June grass sod. These facts show how very necessary cultivation is in a dry climate. That the same is true in dry seasons in moister climates is shown by observations at New York Cornell Station. Part of an orchard was given clean cultivation and another part was seeded to field peas in the spring, to be grown as a green manure crop. In the fall the percentages of moisture at a depth of 12 inches in the green manure plat were 8.7 to 9.6 and in the cultivated plat 11.3 to 12.8. Moreover, in the cultivated soil the moisture was distributed to within 2 inches of the surface of the soil, while in the soil growing field peas the first few inches were exceedingly dry. The tree growth was less vigorous and the leaves lighter colored on the green manure plat than on the other. The leaves of peach trees on the cultivated plat were perfect, while on the green manure plat they turned yellow and fell. Similar differences were seen in the case of apricots, pears, and plums.

The California Station has recently reported an instance of the beneficial effect of cultivation on the growth and fruitfulness of orchards. Apricots grown in adjacent fields under exactly the same conditions, except for cultivation, showed great difference in behavior (fig. 3). The soil of the region in which the orchards are located has a rather loose texture. One orchard was cultivated several inches deep and the other was uncultivated. During one season the trees in the cultivated field made a wood growth of over 3 feet, while those in the uncultivated field made a growth of not over 3 inches. There was also a great difference in the fruit. The average percentage of moisture in the first 6 feet of soil was 6.3 in the cultivated orchard and 4.2 in the other one. A recent bulletin of the Illinois Station reports marked benefit from clean cultivation of an orchard. In 1890 three rows each of Ben Davis and Grimes Golden apples were planted, the trees being set 15 feet apart each way. These were divided into 4 plats, the first being given clean cultivation and the second, third, and fourth being cropped with oats, clover, and blue grass, respectively (fig. 4). The same treatment was continued each year after planting. The trees grown on the grass plats were decidedly inferior to those grown on the cultivated plat as regards height, diameter of trunk, vigor, and abundance of foliage, etc. For instance, in the case of the Ben Davis trees the diameter of the trunks 1 foot above the surface of the soil was about twice as great in the case of the cultivated plat as in case of that in grass. Similarly the height of the trees in the two plats averaged 18¾

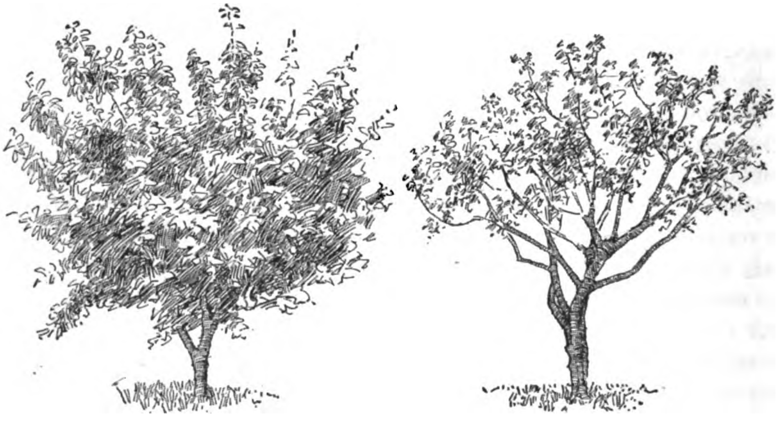

Fig. 3.—Cultivated (*A*) and uncultivated (*B*) apricot trees in a dry season.

and 11 feet, and the diameter of the tops 15½ and 8¼ feet, respectively. In the growth and vigor of trees, the clover plat ranked next after the cultivated plats, and the oats plat ranked between the clover and blue grass plat. An examination of the root systems of trees on the different plats also showed the superiority of clean cultivation, especially over cropping with oats and grass. In the cultivated plat the root system was compact and reached a considerable depth, while in the oats and grass plats the roots grew shallow and ranged widely from the tree. There was also a difference in the moisture content of the soil in the different plats. In the latter part of October, 1897, the average percentages of moisture in the first 27 inches of soil of the various plats were for the cultivated and corn plats 12, for the clover plat 10, and for the oats and grass plats 8. The effect of the different treatments is seen in figure 4 which shows a typical tree from each of the 4 plats.

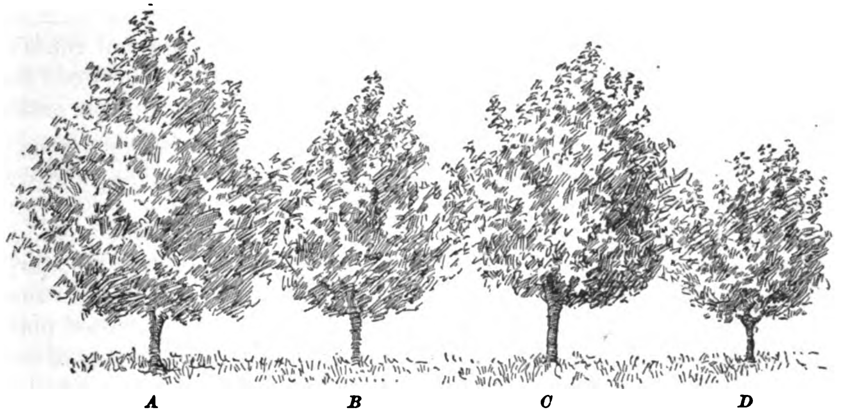

FIG. 4.—Effect of different systems of culture on the growth of apple trees: *A*, clean cultivation; *B*, cropped with oats; *C*, cropped with clover; *D*, cropped with blue grass.

The injury caused by growing grass in young orchards is shown very emphatically by an experiment conducted at the Utah Station. Parts of an orchard were seeded to alfalfa, timothy, clover, and a mixture of timothy and clover soon after the trees were set, and other parts were cultivated, all being irrigated alike. Over half of the trees in the grass plats died and were reset twice, while the cultivated trees lived and grew well. It is not to be expected that growing grass in young orchards is always as injurious as it proved to be at the Utah Station, yet the reported experiences of fruit growers and experimenters everywhere show the importance of carefully cultivating young orchards. Even in a climate as moist as that of England grass proves very detrimental to young trees. At the Woburn Experimental Fruit Farm a mixture of grass recommended for orchards was sown around young apple trees and other trees were cultivated, the two lots being treated alike in other respects. The second year after sowing the grass the trees in the grass plat made 35 to 41 per cent less leaf growth and

74 to 87 per cent less wood growth than trees in the cultivated plat. In the case of dwarf trees bearing fruit for the first time the grass reduced the yield 71 per cent in weight and 82 per cent in value. Grass sod was much more injurious than weeds which lived but one year.

From the experiments referred to above it would appear that the growth of grass, weeds, and even such plants as field peas, through the entire season without cultivation, especially in young orchards, is to be regarded as an injurious practice. The growth of grass, weeds, and cereal crops makes impossible cultivation, which would not only check evaporation of water from the soil, but would also prepare the soil to hold more of the rainfall, make plant food available to the trees, send the tree roots down to the subsoil, and the like. Aside from preventing cultivation, the crops noted evaporate a great amount of water through their leaves, and, if removed from the orchard, rob it of fertility.

Notwithstanding all this, it must not be inferred that clean cultivation is best in all cases. If the trees are set in fertile soil there is usually no injurious effect from growing a secondary crop between the rows while the trees are young and their roots do not occupy the entire soil, but the secondary crop should always be one that requires careful cultivation and does not evaporate moisture excessively, such as beans, peas, potatoes, cabbage, squashes, melons, and the like. The crops noted, and other similar ones, if not planted too close to the trees, do not hinder cultivation, and they evaporate comparatively little moisture. As an example of this, it has been shown at the Nebraska Station that in midsummer the moisture content of the soil of well-cultivated plats of cabbage, beans, peas, and potatoes was but little less than that of cultivated fields in which no crop was growing. Such plants as squashes and melons may hinder cultivation late in the season, but that is usually not a disadvantage, as shown later. As the trees grow the crops should be planted farther from them until the tree roots occupy all the ground, when it is usually best to discontinue growing secondary crops. Orchards with trees set 20 feet apart should rarely be cropped more than three years, but apple orchards can often be cropped for seven or eight years. When the trees begin to bear it is usually time to stop cropping the orchards.

Aside from the growth of secondary crops in orchards, there are other cases where clean cultivation is not best. It often happens that in very rich soil or in very moist localities fruit trees grow vigorously, but do not fruit well. It is then necessary to do something to check the growth and induce fruitfulness. This may often be accomplished by seeding the orchard to grass. How long grass should be allowed to remain can be determined only by the growth, fruitfulness, and appearance of the trees. If the growth becomes very weak and the leaves are light-colored it is an indication that cultivation should be resumed. Indeed, it should have been resumed before these conditions appeared.

Another case in which clean cultivation is not best is where orchards in very light soils are subject to the washing and leaching of heavy rains. In such cases it may be advantageous to grow a secondary crop in summer, to hold the soil and prevent the washing out of food materials. This binding of orchard soils by means of secondary crops may well be combined with the improvement of the soil by green manuring. In the majority of cases, however, this treatment will be found unnecessary. But even where summer treatment is not necessary it is often well to grow some crop to protect the soil and trees during winter and to improve the soil. In this case, then, clean cultivation during the first part of the season may be followed later by the use of some cover crop.

APPLICATION OF WATER PRESSURE TO TRANSPLANTED TREES.

The Wisconsin Station has recently reported experiments in applying slight water pressure to the roots of newly transplanted trees as a means of promoting the starting of their buds, thereby preventing failure in transplanting. A vessel containing a small quantity of water is supported at a height equal to or slightly exceeding that of the tree and connected by a tube with a root of the tree, so that the pressure exerted by the column of water in the tube is communicated to the water within the tree. In the tests made at the station a flask of water was supported on a stake driven in the ground near the tree and a rubber tube used to connect the flask with the root. A simpler and more substantial form of apparatus is recommended for general use (fig. 5). A cup with a small opening in the bottom is soldered to one end of a small gas pipe and a cap screwed on to close the other end. Near the closed end the pipe has a T connected with a brass nipple to which a short rubber tube is attached.

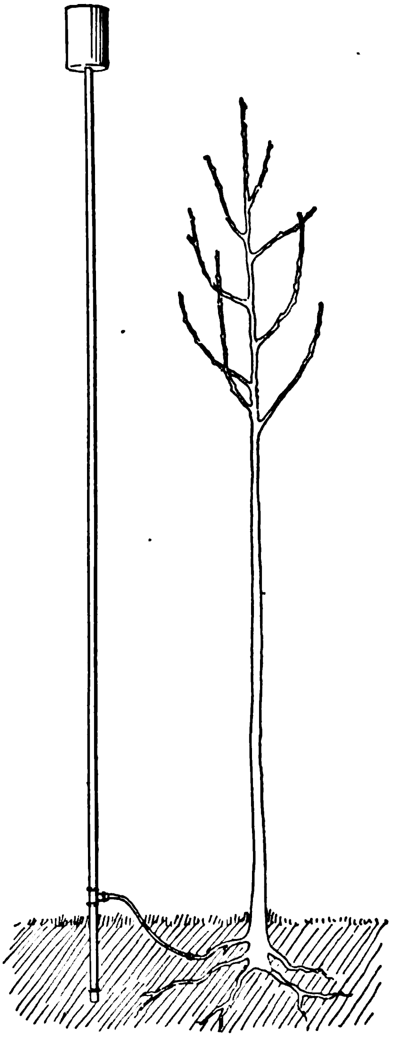

FIG. 5.—Apparatus for applying water pressure to transplanted trees.

The soil is removed from the end of a root and the closed end of the gas pipe shoved into the ground near enough to the tree to allow the rubber tube to slip over the end of the root. The end of the rubber tube is then closed with a cork and the apparatus filled with water, when the cork is removed and the end of the tube slipped over the end of the root and tied with a cord.

The effect of the water pressure was often very quickly noticed, sometimes within forty-eight hours. Pressure was applied in the latter part of May, 1896, to a small purple beech tree which had been planted in April but had shown no indications of opening its buds. Six days later the buds had opened sufficiently to show the leaves plainly. In the middle of May, 1896, water pressure was applied to a tree of the "City" plum which had been planted nearly a month previous. Several leaf buds had opened but had been dried up by hot, dry weather. A week after the pressure was applied many buds which had not opened before began to swell, and in about another week the leaves were pushing out vigorously. In the spring of 1897, twenty Whitney crab-apple trees were planted in rather poor, dry soil. The roots of these trees had been exposed for a time during the winter to the warm, dry atmosphere of the garden house, having been used by students in lessons in

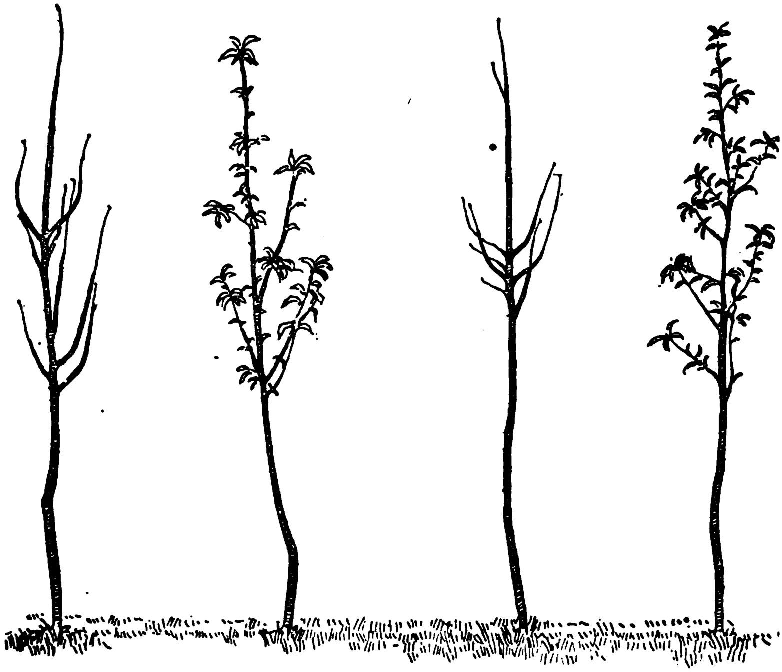

FIG. 6.—Effect of artificial root pressure on the opening of buds.

transplanting, and had then been kept in damp soil in a cellar. During the four days preceding planting the roots were exposed to the air but protected from the rain and snow. The trees were planted in the latter part of April without special care, and water pressure was applied to a root of each alternate tree. The weather was clear, with occasional showers. In one week after planting, the buds on the trees supplied with water pressure began to open, and in two weeks every tree thus treated was starting well. During the next two weeks, with dry, clear weather, the treated trees continued with one exception to expand their leaves. By this time the buds on one of the untreated trees began to start, but those on the other untreated trees showed no sign of starting. (See fig. 6.) Later the ground was well irrigated and mulched. All the trees ultimately grew except two, both failures being in the untreated lot, and by fall little difference could be seen between the trees of the treated lot and the live ones of the untreated lot, showing that the advantage of the treatment is only in starting growth.

The apparatus has not thus far been tested on trees more than four years old nor on evergreens. Whether it will be found advantageous to use this treatment in transplanting large trees can not be said at present. Whether it is found economical in ordinary work or not, it will undoubtedly prove a very valuable means of preventing failure in transplanting trees under unfavorable conditions, especially in the case of rare or otherwise specially valuable trees.

In regard to the practical value of the treatment the bulletin says:

> Trees of which the bark is shriveled and the buds blackened by undue drying, or of which the roots have been killed by severe freezing in a dry soil, can not be saved by this treatment; but trees of which the bark and buds are plump, that are unable to expand their leaves even when the soil about their roots is moist, may generally be assisted to do so by the apparatus here described. The treatment will probably have especial value for trees that it is desired to plant without severe cutting back of the top.

THE FECUNDITY OF SWINE.

The impression is prevalent among farmers that pure-bred swine are unprofitable for breeding purposes, as it is thought that as purity of breed increases fecundity decreases. The question of the fecundity of improved breeds of swine was investigated recently by the Indiana Station. The number of pigs farrowed and raised in the first and the last 200 litters recorded in the registers of Berkshire, Poland-China, and Chester White pigs were compiled. In comparing the litters, 100 litters were selected in which the sows were recorded, and 100 in which the boars were recorded. The dates of farrowing of the first 200 litters varied through a number of years. The last 200 litters were almost all farrowed in 1896. The popular opinion was not confirmed by this investigation.

While there seems to be a reduction in the number of very large litters, the total number farrowed is about the same as shown by the first records.

It is not the intent to compare breeds, but to compare the earliest and latest records of litters, to determine whether there has been a real gain or loss in the fecundity of the breed.

The number of boars and sows raised was as follows: Berkshire, 400 litters, 2,866 pigs, 1,498 boars, 1,368 sows; Poland-China, 1,000 litters, 6,542 pigs, 3,228 boars, 3,314 sows; Chester White, 600 litters, 4,555 pigs, 2,236 boars, 2,319 sows. In a total of 3,693 pigs farrowed, and all raised, there were 1,786 boars and 1,907 sows.

FOOD VALUE OF HENS' EGGS.

Eggs are generally regarded as a valuable and nutritious food. According to a large number of American analyses, an egg on an average weighs 2 ounces and has the following percentage composition: Shell, 10.5; water, 66; protein, 13.1; fat, 9.3; and ash, 0.9. A side of beef contains on an average about the same percentage of protein, but a larger percentage of fat. Eggs belong to the nitrogenous group of foods, and would naturally and quite properly be combined in the diet with materials supplying carbohydrates (sugar and starch), such as cereals, potatoes, etc.

The California Station has recently reported an extended study of the physical properties and chemical composition of eggs, the chief object being to determine whether there was any basis of fact for the popular opinion that eggs with brown shell have a higher food value than those with white shell. The brown-shelled eggs were from Partridge Cochins, Dark Brahmas, Black Langshans, Wyandottes, and Barred Plymouth Rocks, and the white-shelled eggs from Brown Leghorns, Buff Leghorns, White Minorcas, and Black Minorcas. The size, weight, specific gravity, and the ratio to total weight of the shell, yolk, and white are shown in the following table:

Comparison of brown-shelled and white-shelled eggs.

	Weight.	Length	Width.	Specific gravity.	Number of eggs to pound.	Shell.	Edible portion.		
							Total.	Yolk.	White.
	Grams.	*Inches.*	*Inches.*			*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
Brown-shelled eggs (average of 6 breeds)	59.4	2.27	1.69	1.082	7.67	10.70	89.30	31.76	57.54
White shelled eggs (average of 4 breeds)	62.9	2.27	1.76	1.058	7.83	10.92	89.08	33.18	59.90
Average of above	61.2	2.27	1.72	1.070	7.50	10.81	89.19	32.47	56.72

The composition of the eggs of the different breeds is recorded in detail. The averages are given in the following table:

Analyses of brown-shelled and white-shelled eggs.

	Water.	Protein.	Fat.	Ash.	Shell.	Total.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Brown-shelled eggs:						
Yolk	49.59	15.58	33.52	1.04	....	99.73
White	86.60	11.99	.21	.54	....	99.34
Entire egg	65.57	11.84	10.77	.64	10.70	99.52
White-shelled eggs:						
Yolk	49.81	15.49	33.34	1.05	....	99.69
White	86.37	12.14	.35	.56	....	99.42
Entire egg	64.79	11.92	11.22	.67	10.92	99.52

> It has been said by some that the brown eggs are richer than the white ones. This statement is not borne out by a chemical analysis, and the physical examination proves that the main points of superiority, though extremely slight, are possessed by the white eggs. The minute differences that are found between the two groups are exceeded by variation between the varieties within the same group.
>
> We can therefore state as a conclusion, both from a chemical and a physical point of view, that there are practically no differences, so far as the food value is concerned, between the white-shelled and brown-shelled eggs.

The Michigan Station has recently reported a study of the chemical composition of eggs from different breeds of hens. These were Brown Leghorns, Barred Plymouth Rocks, Buff Cochin, Silver Gray Dorkings, White Wyandottes, and Partridge Cochin. The variation in composition of the eggs of the different breeds was too small to be regarded as of any practical value. It would undoubtedly be no greater than the variations between different samples of eggs from the same breed. The effect of the character of rations on the composition of eggs was also tested with two lots of Barred Plymouth Rocks, Wyandottes, and Brown Leghorn hens. The test covered six weeks. Lot 1 was fed a mixture of 1 part of meat scraps, 8 parts of wheat, and 1 part of oil meal. Lot 2 was fed with a mixture of 7 parts of corn, 1 part of tallow, and 2 parts of rice meal. Both lots were given lettuce and oyster shells in abundance. No marked variation in the composition of the eggs due to different rations was observed, but the test is not regarded as conclusive, since it was of short duration.

The value of any food is determined not alone by its composition, but also by its digestibility. It is evident that if two foods have the same composition, but owing to physical properties or other cause the first gives up twice as much material to the body in its passage through the stomach as the second it is much more valuable. In connection with other work the digestibility of eggs was studied at the Minnesota Station. Five experiments were made by means of a pepsin solution to determine the digestibility of eggs cooked under different conditions. Eggs were cooked for 3 minutes at 212° F., giving a "soft-boiled" egg, and for 5 minutes and 20 minutes at the same temperature. An egg boiled 3 minutes and digested for 5 hours in pepsin solution, compared with one boiled 20 minutes and treated in the same way, showed 8.3 per cent undigested protein in the former, against 4.1 per cent undigested protein in the latter. Under similar treatment the egg boiled 5 minutes gave 3.9 per cent undigested protein.

Another trial was then made, in which the eggs were cooked for periods of 5 and 10 minutes in water at 180° F. In both of these cases the protein was entirely digested in 5 hours.

These results would indicate that while the method of cooking has some effect upon the rate of digestibility, it does not materially affect the total digestibility. The results agree quite closely with those reported some years ago by Rubner, a German investigator, who found that 97.1 of the protein of hard-boiled eggs was digested.

At the Minnesota Station a digestion experiment was also made with a healthy man, in which a very considerable portion of the nitrogenous material and fat of the ration was furnished by eggs, the other foods eaten being potatoes, milk, and cream. About 90 per cent of the total nitrogenous material and 90 per cent of the fat consumed were digested. In experiments at the University of Tennessee with healthy men on a diet of bread, milk, and eggs from 90 to 95 per cent each of the protein and fat were digested. The conclusion therefore seems warranted that, as shown by composition and digestibility, eggs possess the high nutritive properties which are popularly assigned to them.

For a number of years this Department has been carrying on food investigations in different parts of the country. One of the objects was to learn the kinds and amounts of food consumed by persons engaged in various occupations and the relative cost of such foods. Compared with other foods at the usual prices, eggs at 12 cents per dozen were found to be a cheap source of nutrients; at 16 cents per dozen, they were fairly expensive; and at 25 cents per dozen and over they were very expensive.

THE SWEET POTATO AS A STARCH PRODUCER.

By far the larger part of the starch of commerce is at present manufactured from corn, potatoes, and rice. Potatoes are largely used on the continent of Europe, rice principally in England, but corn almost exclusively in America. In selecting a starch-producing plant two things must be taken into consideration, (1) the amount of starch yielded per acre and (2) the cost of separating the starch. The general use in the United States of corn as a starch producer is undoubtedly due to its widespread culture, its high content of starch, and the ease and cheapness with which the latter is produced. While it is not likely that any of our common crops can successfully compete with corn as a starch producer under the ordinary conditions at present prevailing in the United States, there may be special conditions under which the utilization of other starch-producing plants may prove profitable.

The sweet potato has frequently been suggested as a possible profitable starch producer, but little has actually been done to determine its value for this purpose. The South Carolina Station has recently made some studies on the sweet potato which have an important bearing on this point. Analyses of samples of potatoes from different sources showed an average starch content of over 20 per cent, running as high as 26 per cent in some cases. In two samples the starch was separated mechanically. In the first, which chemical analysis showed to contain 22.82 per cent of starch, 20.61 per cent was obtained by mechanical means; the second, containing 21.74 per cent, yielded 19.96 per cent by mechanical separation. The material thus separated was quite pure, containing 96 per cent of pure starch.

Assuming a yield of 20 bushels, or 1,200 pounds, of wheat per acre; 35 bushels, or 1,960 pounds, of corn, and 200 bushels, or 1,200 pounds, of sweet potatoes, the yield of starch is estimated to be: From wheat, 684 pounds; corn, 1,283, and sweet potatoes, 2,640. It is thus seen that the amount of starch yielded per acre by sweet potatoes is largely in excess of that yielded by cereals. The sweet potato also appears to have some advantage in this respect over the white potato, which is so largely used in Europe.

Besides the question of the yield of starch, however, there are other things to be taken into consideration, viz, the cost of production of the sweet potato, the changes that may take place in storage, the cost of manufacturing the starch, and, finally, the properties of the starch itself.

It is claimed that a given amount of starch is produced at much less cost in sweet potatoes than in cereals and white potatoes. A fact which must be taken into account, however, in considering the value of the sweet potato for starch manufacture is that there is a considerable change of starch into sugar in storage.

The Texas Station found that "a sweet potato containing 2.77 per cent of total sugar originally, when kept for a month and a half, increased its total sugar content to 11.63 per cent, and in four months still further increased it to 13.8 per cent." The extent of the loss from this source, of course, depends largely upon the length and manner of storage.

> The questions involving the manufacture of the starch on a large scale and the fitness of the product for sizing and other purposes can be best determined by a factory test. It is believed that the results already obtained are sufficiently promising to justify those who are interested in this subject in trying to have a factory test made. * * *
>
> While in communities near large markets the sweet potato always brings a good price, yet in districts removed from market facilities it hardly pays to ship them, and it is in the latter districts that starch factories could no doubt be placed with advantage.

An important factor to be taken into consideration in this connection is the character of the refuse left after extracting the starch. Corn contains considerable amounts of protein, and when used for the manufacture of starch furnishes by-products rich in this constituent, and therefore very valuable feeding stuffs. Gluten meal and feed are examples of these by-products. Sweet potatoes, on the other hand, contain much less protein, and would therefore furnish a much less valuable by-product.

THE TOAD AS A FRIEND OF THE FARMER.

Great and beneficent results are often accomplished through very humble agencies. Darwin has established the claim of the earthworm to the gratitude of the tiller of the soil, and modern science is revealing thousands of hitherto unseen and unknown agencies working in the interests of man. Science now comes forward to establish what a few have long maintained, viz, that the ugly and despised toad is a faithful and efficient servant of the farmer.

From the earliest times, as a bulletin of the Massachusetts Hatch Station states, the toad has been associated in the popular mind with a host of "vague and ludicrous fancies as to its venomous qualities, its medicinal virtues, or, most commonly, the hidden toadstone of priceless value." To these venerable creations of the imagination have been added others equally absurd, such as "that touching toads will produce warts on the hands; that killing toads will produce bloody milk in cows; that a toad's breath will cause convulsions in children; that a toad in a newly dug well will insure a good and unfailing supply of water, or in a new-made cellar will bring prosperity to the household, etc." This station has made an investigation of the habits, food, and economic value of the American toad which dispels these fallacious ideas, and at the same time establishes the claim of the little animal to our consideration and appreciation.

In New England the toad usually emerges from its hibernating quarters during the month of April. Cold weather retards its movements, but on warm days at this season the toads may be found on their way to the ponds and stagnant pools, where a little later the characteristic shrill cry may be heard throughout the day and evening. Mating is commenced as soon as the water is reached, or even before, and in a few days the long slimy "ropes" of eggs deposited by the female may be found in the pools. The eggs are nearly black in color and rapidly increase in size. In two weeks the young tadpoles are clearly outlined, and in three or four weeks the eggs hatch. The vegetable detritus of the pond bottoms and the slime and algæ attached to sticks, plants, etc., seem to be the common food of the tadpole. Warm weather favors the growth of the tadpoles, and usually by July 1 to 15 the young toads are fully developed, leave the water and spread over the fields. At this stage they are exceedingly sensitive to heat, and secrete themselves under leaves, rubbish, stones, etc., during the day; but let a vigorous shower descend and the transformation is magical. The walks, roads, and gardens at once become peopled with myriads of these thirsty, leaping creatures, and their sudden appearance has led to the popular belief that they "rain down." It is fortunate for them that when young they are unable to endure solar heat, otherwise large numbers would probably be destroyed by the birds which are active during the day; doubtless many are killed by the predaceous birds and mammals which prowl by night.

Many conflicting statements have been made regarding the longevity of the toad, but "there can be but little doubt that toads live to a considerably greater age than is supposed, and we may hazard the opinion that many of them reach an age of at least 10 or 15 years."

Experiments have been made which "show that it is possible for the toad to exist for a limited time without food, but throw a shadow of improbability upon the stories of those found in rocks, trees, etc."

When suddenly disturbed or roughly handled the toad ejects a colorless fluid from the anus and a milky liquid from the skin. This habit is probably the basis for the belief that the toad is venomous. The secretion of the skin glands is harmless when applied to the hands, but it evidently possesses acrid properties, since when toads are bitten by dogs or cats the latter usually have a copious flow of saliva, show signs of discomfort, and in some cases coming under the observation of the writer have manifested considerable distress. That this fluid is not objectionable to all animals is apparent from the fact that many hawks, owls, etc., include the toad in their bill of fare.

The toad sheds its skin four or five times each year. There is a popular notion that the toad swallows the molted skin, but this was not observed in this study.

On the approach of cool weather, sometimes as early as the 1st of September, toads begin to seek winter quarters. These they find in cellars, under buildings, rocks, leaves, or rubbish, and in places where the action of frost will not be felt. Cold benumbs them but does not kill.

The toad can not endure high temperatures. Properly speaking, it is a nocturnal animal, and ventures out during the day only when tempted by an abundance of food in its immediate vicinity or when the air is full of moisture. It eats only living and moving insects, centipedes, etc.

The toad's tongue, its only organ for seizing food, is soft, extensile, attached in front but free behind, and is covered with a glutinous substance which adheres firmly to the food seized. So rapid is the motion of this weapon that a careful watch is necessary in order to see the animal feed. * * *

At night, soon after sundown, or even before on cool evenings, the toad emerges from its shelter and slowly hops about in search of food. Something of a regular beat is covered by these animals, whose sense of locality is quite strong. In the country this includes forays along roadsides, into gardens and cultivated fields, and wherever insect food is abundant and grass or other thick herbage does not prevent locomotion. In cities and suburban villages the lawns, walks, and particularly the spots beneath electric lamps, are favorite hunting grounds.

The toad as a rule feeds continuously throughout the night, consuming in twenty-four hours an amount of food equal in bulk to about four times the stomach capacity.

A careful examination of the contents of the stomachs of a large number of toads showed that 98 per cent of its food was animal matter—worms, insects, etc. "Eleven per cent of the toad's food is composed of insects and spiders beneficial or indirectly helpful to man; 80 per cent of insects and other animals directly injurious to cultivated crops or in other ways obnoxious to man." It is estimated that a single toad destroys in a year insects which, if they had lived, might have damaged crops to the extent of about $20.

To all agriculturists the toad renders conspicuous service, but gardeners and greenhouse owners may make this animal of especial value. Every gardener should aim to keep a colony of toads among his growing crops and the practice of collecting and transferring them to the gardens is a commendable one. While the sense of locality is strong in this batrachian and it will often return over considerable distances to its original haunts, yet it may be induced to remain in new quarters if there is a sufficient food supply. * * *

The crow and various species of hawks and owls are the chief natural enemies of the toad, but as a common enemy of the toad the ubiquitous small boy plays a prominent part. Seventeen toads dead and more or less mutilated were once observed at Malden, Mass., lying on the shores of a small pool. This was the result of a couple of hours' amusement on the part of two juveniles.

This is not an extreme case. Such cruel and senseless persecution is only of too common occurrence. The loud cry of the toad at spawning time readily betrays its presence, and small boys, and sometimes those of larger growth, gravitate toward the pools as naturally as do the toads themselves. There have been excellent laws enacted to protect our insectivorous birds. Why should there not be as stringent legislation against the destruction of toads? If merit of service rendered to man be the standard by which legislation is determined, the toad presents a record which will compare favorably with that of any insectivorous bird. Public sentiment in a matter like this, however, exerts a stronger influence than legislation, and when the services of this animal are appreciated and the toad receives in our public schools recognition similar to that given to the birds, then we may expect to see a lessening of the wanton destruction of this humble servant of man.

EXPLANATION OF TERMS.

TERMS USED IN DISCUSSING FERTILIZERS.

Complete fertilizer is one which contains the three essential fertilizing constituents, i. e., nitrogen, phosphoric acid, and potash.

Nitrogen exists in fertilizers in three distinct forms, viz, as organic matter, as ammonia, and as nitrates. It is the most expensive fertilizing ingredient.

Organic nitrogen is nitrogen in combination with other elements either as vegetable or animal matter. The more valuable sources are dried blood, dried meat, tankage, dried fish, and cotton-seed meal.

Ammonia is a compound of nitrogen more readily available to plants than organic nitrogen. The most common form is sulphate of ammonia, or ammonium sulphate. It is one of the first products that results from the decay of vegetable or animal substances.

Nitrates furnish the most readily available forms of nitrogen. The most common are nitrate of soda and nitrate of potash (saltpeter).

Phosphoric acid, one of the essential fertilizing ingredients, is derived from materials called phosphates. It does not exist alone, but in combination, most commonly as phosphate of lime in the form of bones, rock phosphate, and phosphatic slag. Phosphoric acid occurs in fertilizers in three forms—soluble, reverted, and insoluble phosphoric acid.

Potash, as a constituent of fertilizers, exists in a number of forms, but chiefly as chlorid or muriate and as sulphate. All forms are freely soluble in water and are believed to be nearly, if not quite, equally available, but it has been found that the chlorids may injuriously affect the quality of tobacco, potatoes, and certain other crops. The chief sources of potash are the potash salts from Stassfurt, Germany—kainit, sylvinit, muriate of potash, sulphate of soda, and sulphate of potash and magnesia. Wood ashes and cotton-hull ashes are also sources of potash.

TERMS USED IN DISCUSSING FOODS AND FEEDING STUFFS.

Water is contained in all foods and feeding stuffs The amount varies from 8 to 15 pounds per 100 pounds of such dry materials as hay, straw, or grain to 80 pounds in silage and 90 pounds in some roots.

Dry matter is the portion remaining after removing or excluding the water.

Ash is what is left when the combustible part of a feeding stuff is burned away. It consists chiefly of lime, magnesia, potash, soda, iron, chlorin, and carbonic, sulphuric, and phosphoric acids, and is used largely in making bones. Part of the ash constituents of the food is stored up in the animal's body; the rest is voided in the urine and manure.

Protein (nitrogenous matter) is the name of a group of substances containing nitrogen. Protein furnishes the materials for the lean flesh, blood, skin, muscles, tendons, nerves, hair, horns, wool, casein of milk, albumen of eggs, etc., and is one of the most important constituents of feeding stuffs.

Gluten is the name given to one of the most important of the nitrogenous substances classed together under the general term "protein." "Wheat gum," obtained by carefully chewing wheat, is a familiar example. It is the gluten of flour that gives consistency to dough.

Carbohydrates.—The nitrogen-free extract and fiber are often classed together under the name of carbohydrates. The carbohydrates form the largest part of all vegetable foods. They are either stored up as fat or burned in the body to produce heat and energy. The most common and important carbohydrates are sugar and starch.

Fiber, sometimes called crude cellulose, is the framework of plants, and is, as a rule, the most indigestible constituent of feeding stuffs. The coarse fodders, such as hay and straw, contain a much larger proportion of fiber than the grains, oil cakes, etc.

Nitrogen-free extract includes starch, sugar, gums, and the like, and forms an important part of all feeding stuffs, but especially of most grains.

Fat, or the materials dissolved from a feeding stuff by ether, is a substance of mixed character, and may include, besides real fats, wax, the green coloring matter of plants, etc. The fat of food is either stored up in the body as fat or burned to furnish heat and energy.

MISCELLANEOUS TERMS.

Alkali soils.—Soils found in arid or semiarid regions, which contain an unusual amount of soluble mineral salts (alkali), which effloresce or bloom out in the form of a white powder or crust in dry weather following rains or irrigation. Two distinct classes of alkali are known: white alkali, composed largely of sulphate of soda and common salt, which is comparatively harmless; and black alkali, composed largely of carbonate of soda, which is highly corrosive and destructive to vegetation.

Humus is the name applied to the partially decomposed organic (animal and vegetable) matter of the soil. It is the principal source of nitrogen in the soil.

Leguminous plant is a plant of the botanical order Leguminosæ, the principal representatives of which are clover, peas, beans, etc.

Specific gravity of solid substances is the ratio of the weight of a given bulk of the body to that of an equal bulk of water; or, stated in another way, the ratio of the weight of the substance in air to its weight in water.

Pepsin.—A substance (ferment) found in the juices of the stomach, which aids in the digestion of food. It is prepared in a comparatively pure state on a commercial scale from the lining membrane of pigs' stomachs.

FARMERS' BULLETINS.

These bulletins are sent free of charge to any address upon application to the Secretary of Agriculture, Washington, D. C. Only the following are available for distribution:

No. 15. Some Destructive Potato Diseases: What They Are and How to Prevent Them. No. 16. Leguminous Plants for Green Manuring and for Feeding. No. 18. Forage Plants for the South. No. 19. Important Insecticides: Directions for their Preparation and Use. No. 21. Barnyard Manure. No. 22. Feeding Farm Animals. No. 23. Foods: Nutritive Value and Cost. No. 21. Hog Cholera and Swine Plague. No. 25. Peanuts: Culture and Uses. No. 26. Sweet Potatoes: Culture and Uses. No. 27. Flax for Seed and Fiber. No. 28. Weeds; and How to Kill Them. No. 29. Souring of Milk and Other Changes in Milk Products. No. 30. Grape Diseases on the Pacific Coast. No. 31. Alfalfa, or Lucern. No. 32. Silos and Silage. No. 33. Peach Growing for Market. No. 31. Meats: Composition and Cooking. No. 35. Potato Culture. No. 36. Cotton Seed and Its Products. No. 37. Kafir Corn: Characteristics, Culture, and Uses. No. 38. Spraying for Fruit Diseases. No. 39. Onion Culture. No. 40. Farm Drainage. No. 41. Fowls: Care and Feeding. No. 42. Facts About Milk. No. 43. Sewage Disposal on the Farm. No. 44. Commercial Fertilizers. No. 45. Some Insects Injurious to Stored Grain. No. 46. Irrigation in Humid Climates. No. 47. Insects Affecting the Cotton Plant. No. 48. The Manuring of Cotton. No. 49. Sheep Feeding. No. 50. Sorghum as a Forage Crop. No. 51. Standard Varieties of Chickens. No. 52. The Sugar Beet. No. 53. How to Grow Mushrooms. No. 54. Some Common Birds in Their Relation to Agriculture. No. 55. The Dairy Herd: Its Formation and Management. No. 56. Experiment Station Work—I. No. 57. Butter Making on the Farm. No. 58. The Soy Bean as a Forage Crop. No. 59. Bee Keeping. No. 60. Methods of Curing Tobacco. No. 61. Asparagus Culture. No. 62. Marketing Farm Produce. No. 63. Care of Milk on the Farm. No. 64. Ducks and Geese. No. 65. Experiment Station Work—II. No. 66. Meadows and Pastures. No. 67. Forestry for Farmers. No. 68. The Black Rot of the Cabbage. No. 69. Experiment Station Work—III. No. 70. The Principal Insect Enemies of the Grape. No. 71. Some Essentials of Beef Production. No. 72. Cattle Ranges of the Southwest. No. 73. Experiment Station Work—IV. No. 74. Milk as Food. No. 75. The Grain Smuts. No. 76. Tomato Growing. No. 77. The Liming of Soils. No. 78. Experiment Station Work—V. No. 79. Experiment Station Work—VI. No. 80. The Peach Twig-borer: An Important Enemy of Stone Fruits. No. 81. Corn Culture in the South. No. 82. The Culture of Tobacco. No. 83. Tobacco Soils. No. 84. Experiment Station Work—VII. No. 85. Fish as Food. No. 86. Thirty Poisonous Plants. No. 87. Experiment Station Work—VIII. No. 88. Alkali Lands. No. 89. Cowpeas. No. 90. The Manufacture of Sorghum Sirup. No. 91. Potato Diseases and Their Treatment. No. 92. Experiment Station Work—IX. No. 93. Sugar as Food. No. 94. The Vegetable Garden. No. 95. Good Roads for Farmers. No. 96. Raising Sheep for Mutton. No. 97. Experiment Station Work—X. No. 98. Suggestions to Southern Farmers. No. 99. Three Insect Enemies of Shade Trees. No. 100. Hog Raising in the South. No. 101. Millets. No. 102. Southern Forage Plants. No. 103. Experiment Station Work—XI. No. 104. Notes on Frost. No. 105. Experiment Station Work—XII. No. 106. Breeds of Dairy Cattle. No. 107. Experiment Station Work—XIII. No. 108. Saltbushes. No. 109. Farmers' Reading Courses. No. 110. Rice Culture in the United States. No. 111. Farmer's Interest in Good Seed. No. 112. Bread and Bread Making. No. 113. The Apple and How to Grow It. No. 114. Experiment Station Work—XIV. No. 115. Hop Culture in California. No. 116. Irrigation in Fruit Growing. No. 117. Sheep, Hogs, and Horses in the Northwest. No. 118. Grape Growing in the South. No. 119. Experiment Station Work—XV. No. 120. Insects Affecting Tobacco. No. 121. Beans, Peas, and Other Legumes as Food. No. 122. Experiment Station Work—XVI. No. 123. Red Clover Seed: Information for Purchasers. No. 124. Experiment Station Work—XVII. No. 125. Protection of Food Products from Injurious Temperatures. No. 126. Practical Suggestions for Farm Buildings. No. 127. Important Insecticides. No. 128. Eggs and Their Uses as Food. No. 129. Sweet Potatoes. No. 130. The Mexican Cotton Boll Weevil. No. 131. Household Test for Detection of Oleomargarine and Renovated Butter. No. 132. Insect Enemies of Growing Wheat. No. 133. Experiment Station Work—XVIII. No. 134. Tree Planting in Rural School Grounds. No. 135. Sorghum Sirup Manufacture. No. 136. Grape Culture in the North. No. 137. The Angora Goat. No. 138. Irrigation in Field and Garden.

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U. S. DEPARTMENT OF AGRICULTURE.

FARMERS' BULLETIN No. 88.

ALKALI LANDS.

BY

MILTON WHITNEY AND THOMAS H. MEANS.

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LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Division of Soils,
Washington, D. C., January 4, 1899.

Sir: The interest taken in the alkali work of this division in Montana during the summer of 1898 has been so widespread, and there have been so many requests for copies of a technical bulletin upon the subject, which is just about to be issued, that it has been thought proper to present the matter in a rather more popular style, leaving out some of the technical descriptions and the expensive illustrations, in order that it may have very wide circulation. This material, while almost entirely rewritten, is essentially the same as that contained in Bulletin No. 14 of this division.

I recommend that this be published as a Farmers' Bulletin.

Respectfully,

Milton Whitney,
Chief of Division.

Hon. James Wilson,
Secretary of Agriculture.

CONTENTS.

	Page.
Introduction	5
The conditions in the Yellowstone Valley	6
The rainfall and seepage	8
How the salt determinations are made	9
The kinds of soil in the valley	9
Salt content of the soil	10
Effect of underdrainage in removing salts	16
Summary of the investigations and conclusions	20

ILLUSTRATION.

FIG. 1. The salt content of sandy land and gumbo, with and without irrigation 13

ALKALI LANDS.

INTRODUCTION.

Alkali and the treatment of alkali soils are subjects which are attracting very great attention at the present time, as alkali has already injured or is a serious menace to large areas of land. It is encountered in all arid districts the world over. It is always a source of uneasiness in such sections, for if the alkali is not apparent when the lands are first irrigated it is liable to appear after a few years as a result of the present system of irrigation. The uncertainty itself, and the serious nature of the trouble, calls for most energetic measures for the prevention of injury and the reclamation of ruined lands. Lands which a few years ago showed no signs of alkali, but, on the contrary, were extremely fertile, and upon which large amounts of money have been expended in farm improvements, are now, after ten, fifteen, or twenty years, being ruined by an accumulation of seepage waters and of soluble salts.

It is not intended at this time to undertake a general discussion of the alkali problem, as it will require many years of constant work to obtain an accurate knowledge of the conditions over the arid regions of this country. But the results of some investigations carried on during the summer of 1898 in the Yellowstone Valley are so important and of such widespread practical application and value that they are published in this form to help stimulate an interest in the subject, and to show, under certain conditions at any rate, that the means for the prevention of the rise of alkali and for the reclamation of alkali lands are well within the power of the farmer.

In taking up the study of the alkali problem the division was fortunate in selecting the Yellowstone Valley, where the conditions are as simple as can be found anywhere. There are many other areas in this country where the conditions are quite as simple, and where the matter can be brought under just such control as there, while there are much more difficult problems in other sections, due to location and topography of land, to the small available water resources, to the texture of the soil, and to the kind and distribution of the alkali.

THE CONDITIONS IN THE YELLOWSTONE VALLEY.

The investigations were carried on near Billings, Mont. At this place the Yellowstone Valley is from 6 to 10 miles wide. The valley is about 400 miles long in Montana, and irrigation is spreading from a number of centers within this area.

Irrigation has been practiced at Billings for the past twelve or fifteen years. The water for the main irrigation canal, supplying the valley at this place, is taken out of the Yellowstone River nearly 40 miles above the town of Billings. When the country was first settled (and, indeed, at the present time, in the area above the ditch) the depth to standing water in the wells was from 20 to 50 feet, and there were no signs of alkali on the surface of the ground. Under the common practice of irrigation, however, an excessive amount of water has been applied to the land, and seepage waters have accumulated in the soil to such an extent that water is now commonly found in wells throughout the irrigated district at a depth of from 3 to 10 feet from the surface. Many large tracts of once fertile lands on the lower levels are already flooded, and alkali has accumulated on them to such an extent that they are mere bogs, swamps, or alkali flats. This injury, while not very widespread as yet, has been so serious where the results have appeared, and the future is so uncertain that the owners of the land are naturally very much concerned. This is but too common a history of many large and fertile areas in Utah, in southern California, in Colorado, and, in fact, in nearly all of the older irrigated districts.

The valley at Billings is bounded on the north side by a sandy bluff of gray siliceous stone rising abruptly to a height of from 200 to 500 feet above the general level of the valley. On the south side there are steep, ragged hills of blue slate or shale. This shale dips down and passes under the sandstone bluffs about on a level with the present surface of the valley. The valley lands have been formed by the disintegration of both the sandstone and shale. In places the sandstone has been entirely worn away, leaving the soil formed from the disintegration of the shale exposed in places throughout the valley. This soil is stiff gumbo. The shale is very deep, borings for an artesian well having been made to a depth of 900 feet, and through the whole depth this shale has been found. In other parts of the valley the sandstone has not been so completely removed, and there are large areas of sandy or loam soils with the gumbo subsoil at a considerable depth below the surface. These areas are recognized as sandy soils, while the others are classed as gumbo. There are mixtures, of course, grading from one to the other, and these mixed soils are the most abundant in the valley.

Both the sandstone and the shale rocks contain large quantities of soluble salts, which are seen as shining crystals throughout the mass. The shale, however, contains very much more than the sandstone.

As the rocks have disintegrated through the influence of the weather the minerals have been broken down into simple mineral salts that have remained as soluble salts in the soil. The reason for this accumulation is the small annual rainfall occurring in the arid regions. It is so little and the drainage is so slight that the salts accumulating from the disintegration of the rocks are not carried off into the ocean, as is the case in the soils of the humid regions. In the Eastern States, with an annual rainfall of 40 inches, nearly half of this leaches down through the subsoil and eventually finds its way through the streams and rivers into the ocean. This carries with it the greater portion of the soluble salts, as they are set free in the disintegration of the rocks. With less than 10 inches of rainfall, as occurring in the arid portion of the United States, the drainage is extremely small, and there is no natural means provided, therefore, for removing the salts as they are formed. This accumulation explains at once the wonderful fertility of the lands generally in the arid regions the world over, but it is also a constant menace because of the large amount of soluble salts which is liable to accumulate locally as the result of irrigation or as a result of other natural conditions not well understood, until they are a menace and often a destructive agency for the very lands which were formerly held in such esteem.

In the formation of the valley soils at Billings from the decomposition of the sedimentary rocks undoubtedly part of the soluble salts have been removed. Furthermore, as the drainage through the sandy soils is much freer than through the gumbo, and as there is less salt to start with in the sandstone rock than in the shale, it is natural to suppose that there is less of the soluble salts in the sandy soils of the valley at the present time than in the gumbo soils, and this is a fact proved by the investigations.

The alkali soils of the West are of two principal classes: The alkaline carbonates or black alkali (usually sodium carbonate) is the worst form, actually dissolving the organic materials of the soil and corroding and killing the germinating seed or roots of plants; the white alkalies, the most common of which are sodium sulphate, sodium chloride, magnesium sulphate, and magnesium chloride, are not in themselves poisonous to plants, nor do they attack the substance of the plant roots, but are injurious when, owing to their presence in excessive amounts, they prevent the plants from taking up their needed food and water supply.

The amount of soluble salts which plants can stand depends upon the character of the salt, the character of the soil, and the kind of plant. Hilgard states that few plants can stand as much as 0.1 of 1 per cent of sodium carbonate, or about 3,500 pounds per acre to a depth of 1 foot; of sodium chloride plants can stand about 0.25 of 1 per cent, and of sodium sulphate 0.45 to 0.50 of 1 per cent. Plants can stand less salts in sandy lands than on heavy clay or gumbo lands. It is a well-known fact that crops also differ in their ability to stand salts, and many crops will grow well upon soils on which others will not live.

Dr. F. W. Traphagen, of the Montana Experiment Station, finds that the composition of the salt appears to be quite uniform throughout that portion of the valley which was examined around Billings. The following table gives the mean of five analyses which he made:

Composition of the soluble salts at Billings, Mont.

	Per cent.
Sodium sulphate	57.44
Magnesium sulphate	27.59
Calcium sulphate	13.05
Potash sulphate	1.55
Silica	.36
Total	99.99

The soluble salts at Billings are thus seen to be mainly sodium sulphate and magnesium sulphate, with none of the destructive sodium carbonate. There is but a trace, likewise, of sodium chloride. The soils all abound with calcium sulphate or gypsum.

It has been found that the solid grains of soil have the remarkable power of absorbing or concentrating a portion of the salts on their surface and thus withdrawing them from active solution. This is of the greatest practical importance, as otherwise the soil moisture would quickly become saturated with salts and rendered totally unfit for agricultural plants. As a matter of fact, in consequence of this condensing power, in no case was the concentration of the soil moisture found to exceed 3 per cent, although the salts were quite soluble and were crystallized out on the surface of the ground.

The investigations at Billings showed that when the concentration of the salts in active solution in the soil moisture is as great as 1 per cent the limit of most cultivated plants is reached. Further concentration kills all our ordinary agricultural crops. It was found, furthermore, that plants could just exist with 0.45 of 1 per cent of the soluble salts present, equivalent to about 15,000 pounds per acre-foot, and this is taken as the limit of plant production. The soluble salt content of soils in the humid portion of the United States ranges from 50 pounds per acre-foot in the sandy soils of the Atlantic coast to as much as 3,000 or 4,000 pounds in some of the heavier agricultural soils. The average amount would be considerably less than 1,000 pounds per acre-foot.

THE RAINFALL AND SEEPAGE.

There are no available records of the amount of rainfall at Billings, but at Miles City, about 130 miles northeast, the Weather Bureau records show an average annual rainfall of 12.8 inches. From May to September, inclusive, there are 6.7 inches, and during July and August 1.3 inches.

When the rains occur in the spring and wet the surface of the ranges, vegetation flourishes in the most luxuriant way and the grasses give very good grazing. The rains, however, appear to be only sufficient to wet the surface to a very slight depth; the water is quickly used up, and true desert conditions prevail during the summer time.

It appears that in the dry season the soil is moist from 3 feet down, but so slightly moist and the depth of the dry material is so great that it is altogether unlikely that the spring rains pass down to any appreciable extent locally in any one year. The conditions, therefore, are unfavorable to a natural leaching of these soluble salts, except through the exceedingly slow movement there may be in the slightly moist subsoil.

HOW THE SALT DETERMINATIONS ARE MADE.

In the investigations of the conditions at Billings samples were taken with a long extension auger, and salt determinations were made for every foot in depth down to a depth, often, of 10 or 15 feet. The salt was determined by the electrical method, which has been described in previous bulletins of this division. The instruments used in this method are exceedingly sensitive, and determinations made by them are so very rapid that a large number of samples may be examined in the field. Examinations were made in the different types of soil, that is, in the sandy lands, in the stiff gumbo soils, and in the various intermediate grades that were found. Then several lines of borings were made above and below the irrigating canal and from the alkali flats back to the good lands in order to get an idea of the relation of the texture of the soil and the position of the irrigating canal to the alkali problem. Finally a very detailed examination was made of a section of land containing an alkali flat, and maps were constructed showing the distribution of the seepage waters and soluble salts at various levels under the surface of the ground. The value of such underground maps can hardly be overestimated. It is seen just where the seepage waters and the soluble salts are accumulating, from which direction they are coming, and just how drainage systems should be introduced to remove the trouble. They show which areas are safe for a number of years, those which will need careful attention to prevent the accumulation of salts, and those which need energetic measures for the reclamation of lands already damaged.

THE KINDS OF SOILS IN THE VALLEY.

The following table gives the mechanical analyses of a number of soils from Billings which indicate the difference in the texture of the soils which has been noticed.

Mechanical analyses of soils.

No.	Locality. (Miles from Billings.)	Description.	Moisture in air-dry sample.	Organic matter.	Gravel. (2 to 1 mm.)	Coarse sand. (1 to 0.5 mm.)	Medium sand. (0.5 to 0.25 mm.)	Fine sand. (0.25 to 0.1 mm.)	Very fine sand. (0.1 to 0.05 mm.)	Silt. (0.05 to 0.01 mm.)	Fine silt. (0.01 to 0.005 mm.)	Clay. (0.005 to 0.0001 mm.)
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
3756	2½ N........	Sandstone bluff soil.	1.22	2.66	0.00	0.00	0.17	29.39	52.34	3.29	0.88	9.65
3322	11 W........	Silty type, creek soil.	2.98	4.40	0.00	0.00	0.16	7.96	28.79	34.45	4.67	17.25
3309	5½ W........	Sandy gumbo....	1.56	4.66	0.00	0.00	0.20	11.72	45.05	14.69	3.49	19.90
3308	5½ W........	.....do...........	1.94	3.30	0.00	0.10	0.46	15.61	39.59	14.63	3.86	21.30
3307	5½ W........	.....do...........	2.35	3.72	0.00	0.02	0.32	21.37	38.27	8.99	3.13	22.55
3306	3 W........	Gumbo	3.20	3.30	0.01	0.40	1.58	20.40	27.67	11.71	4.02	27.30
3769	5 W........	Heavy gumbo....	3.74	4.22	0.04	0.03	0.19	11.65	24.03	15.13	4.40	35.55

The first sample is a very pure type of sandstone soil taken from the top of the bluff about 2½ miles north of Billings and was derived from the decomposition of the soft layers of fine sandstone which cap the bluffs. These soils are very light and loose and have very free underdrainage. As a matter of fact they leach readily and, although they afford the best possible conditions for irrigation in that seepage waters are not likely to accumulate in them, it is probable that they would not last very long, as the soluble salts would easily and quickly be removed from them. Soils of this type are found in many parts of the valley, and there is little or no danger from seepage waters or from an accumulation of soluble salts at the surface, although they contain considerable quantities of such salts at depths below the surface.

The other samples in the table are seen to grade up through the mixed sandy gumbo to the pure form of gumbo with from 27 to 35 per cent of clay. The mixed soils are the most abundant in the valley.

SALT CONTENT OF THE SOIL.

Salt determinations made in the sandy type of soil above the ditch, where irrigation had never been practiced, and below the ditch, where irrigation had been carried on for ten or twelve years, showed that there was no excessive accumulation of soluble salts, but, on the contrary, that irrigation had really leached part of the salts out of the soil.

The following table gives the results of the salt determinations in a number of places in the sandy soil both above and below the ditch:

Soluble salt content in sandy land.

Depth (feet).	Unirrigated.				Irrigated.					
	Boring 62.		Boring 64.		Boring 26.		Boring 27.		Boring 28.	
	Per cent of salt.	Pounds per acre-foot.	Per cent of salt.	Pounds per acre-foot.	Per cent of salt.	Pounds per acre-foot.	Per cent of salt.	Pounds per acre-foot.	Per cent of salt.	Pounds per acre-foot.
0- 1	0.033	1,155	0.042	1,470	0.046	1,610	0.038	1,330	0.033	1,155
1- 2	.019	665	.041	1,435	.049	1,715	.045	1,575	.037	1,296
2- 3	.045	1,575	.035	1,225	.052	1,820	.044	1,540	.028	980
3- 4	.027	945	.038	1,330	.066	2,310	.051	1,785	.030	1,050
4- 5	.032	1,120	.045	1,575	.097	3,395	.060	2,100	.048	1,680
5- 6	.028	980	.055	1,925	.106	3,710	.051	1,785	.048	1,680
6- 7	.019	665	.056	1,960	.128	4,480	.064	2,240	.048	1,680
7- 8	....	....	.170	5,950	.147	5,145	.070	2,450	.047	1,645
8- 9	....	....	.238	8,330	.112	3,920	.049	1,715	.047	1,645
9-10	....	....	.243	8,505	.112	3,920	.049	1,715	.047	1,645
10-11	....	....	.205	7,175	.056	1,960	.072	2,520	.044	1,540
11-12	....	....	.120	4,200	.056	1,960	.072	2,520	.044	1,540
12-13	....	....	.163	5,705	.058	2.030	.072	2,520	.044	1,540
13-14	....	....	.228	7,980	.058	2,030	.072	2,520	.044	1,540
14-15	....	....	.178	6,230	.058	2,030	.072	2,520	....	....

The limit of excess of alkali in soils at Billings, as already stated, was found to be about 0.45 of 1 per cent. This is equivalent to about 15,000 pounds per acre 1 foot deep. It will be seen from the table that there is not sufficient soluble matter to a depth of 15 feet in this sandy soil to prevent the growth of agricultural plants. It is interesting to note that the amount of soluble salt in the upper 7 feet of the unirrigated soil is particularly small; there is 50 per cent more, perhaps, than is ordinarily found in the soils of the humid region. Below a depth of 7 feet, however, the amount of salt is considerably increased. It would appear that there were evidences here of a slow downward movement of soil moisture, and that under these constant conditions of slow seepage the amount of salt in the upper layers of the soil was constantly diminishing. No examinations could readily be made of the soil below a depth of 15 feet, as this was the extreme length of the auger, but from information furnished by some well-diggers thoroughly familiar with the locality it was learned that the soluble salt content in wells above the canal increases below this to very large proportions. White layers, strongly impregnated with salts, are said to be found below this depth. The water from the wells contains too much of the salts to be of use for domestic purposes, although it is not so strong as to be harmful to cattle.

It is quite reasonable to suppose that the soluble salts had originally been uniformly distributed throughout the upper layers of these soils and that from storm waters and the slow seepage of the slight amount of moisture which the subsoil contains the soluble material had been washed down from the upper layers. Certain it is that similar results follow from the first effect of irrigation where there is good underdrainage, as generally prevails in this sandy soil. In the irrigated sandy land the amount of soluble matter, even to a depth of 15 feet, is comparatively small and the amount throughout the whole depth is quite uniform. This indicates very strongly that the salts have been leached out of the soil and carried off in the underground drainage waters. The examination of the water in a well situated in this irrigated area of the sandy land gives additional proof that some of the salts have been removed. There is a well at the southwest corner of sec. 2, T. 1 S., R. 25 E., near boring 44, in which the water contains 0.119 of 1 per cent of soluble matter, or 60 grains per gallon. Other wells throughout the irrigated area frequently contain as much as 0.4 of 1 per cent of salts.

The heavier type of soil—that is, the gumbo soil—was shown to be derived from the disintegration of the shale. The still undecomposed shale in the bluffs on the south side of the valley was found to be penetrated in every direction with veins of gypsum and the soft shale itself to be permeated with large quantities of sodium and magnesium sulphates. The soils resulting from the disintegration of the shale form a heavy, sticky, blue clay, quite impervious to water. The drainage is so slow through this fine, impervious material that large quantities of the salts remain in the soil.

On account of the poor drainage and the slow movement of the subsoil waters through this material there is great danger of overirrigation, and the problem of irrigation, which is easy on the well-drained, sandy lands, becomes far more complicated and much more difficult to manage on these heavy gumbo soils. Great care has to be taken not only in the application of water, but in the actual cultivation of these soils, as they are liable to be ruined, for a time at least, for alfalfa. On account of the large water content, the fineness of the particles. and the amount of salts these soils contain they easily puddle and get still more impervious to water, and if they are worked when too wet clods form, and it is very difficult to reduce the field again to a good tilth.

On account of these properties the heavier or gumbo soils have to be farmed with very great care. Not only so, but there is great danger from seepage waters from neighboring plantations on higher levels. The soils themselves are naturally extremely fertile and very strong, and last very well if properly cared for. The following table gives the results of salt determinations in typical gumbo soil above the ditch, which has never been irrigated:

Salt content of a heavy unirrigated gumbo soil.

Depth (feet).	Per cent of salt.	Pounds per acre-foot.
0-1	0.035	1,225
1-2	.038	1,330
2-3	.054	1,890
3-4	.200	7,000
4-5	.333	11,655
5-6	.337	11,795
6-7	.253	8,855
7-8	.253	8,855
8-9	.282	9,870

It is apparent from the table that there is a considerable quantity of salt at a depth of 5 feet, and from there down. This boring, with others, is illustrated graphically in fig. 1.

When water is applied to the gumbo soil in the practice of irrigation, the first effect, as in the case of sandy land, is to reduce the amount of soluble salts in the upper layers of the soil. If there is good drainage, this excess of salt may be removed altogether from the soil. If the drainage through the gumbo is slow and inefficient, or, in the case of the sandy land, when underlaid with a compact gumbo subsoil where the drainage is poor, then, in the case of overirrigation, seepage waters will collect, owing to the inability of the soil to remove the water as fast as the excessive quantities are applied.

The following table gives the salt content from several places in one of the alkali flats so formed:

Salt determinations in an alkali flat.

Depth (feet).	Boring 36.		Boring 49.		Boring 52.	
	Per cent of salt.	Pounds per acre-foot.	Per cent of salt.	Pounds per acre-foot.	Per cent of salt.	Pounds per acre-foot.
0-1	0.757	24,710	0.792	27,720	0.229	8,015
1-2	.714	34,570	.920	32,200	.191	6,685
2-3	.634	21,105	.944	33,040	.182	6,370
3-4	.612	21,035	.792	27,720	.175	6,125
4-5	.589	20,965	.519	18,165	.159	5,565
5-6	.187	6,650	.519	18,165	.213	7,455
6-7	....	....	.357	12,495	....	....
7-8	....	....	.357	12,495	....	....
8-9	....	....	.292	10,220	....	....

It will be seen that in boring 36 the salt has accumulated to enormous proportions in the top 5 feet of the soil. The conditions show that the solution is so strong that a white crust is formed over the surface. However, on account of the absorptive powers of the soil, the solution immediately under this crust and in contact with the soil was only 3 per cent, notwithstanding the fact that the salt ordinarily is very soluble in water. This strength solution, however, is entirely too strong for any cultivated crop, and the alkali flat presented a very desolate appearance.

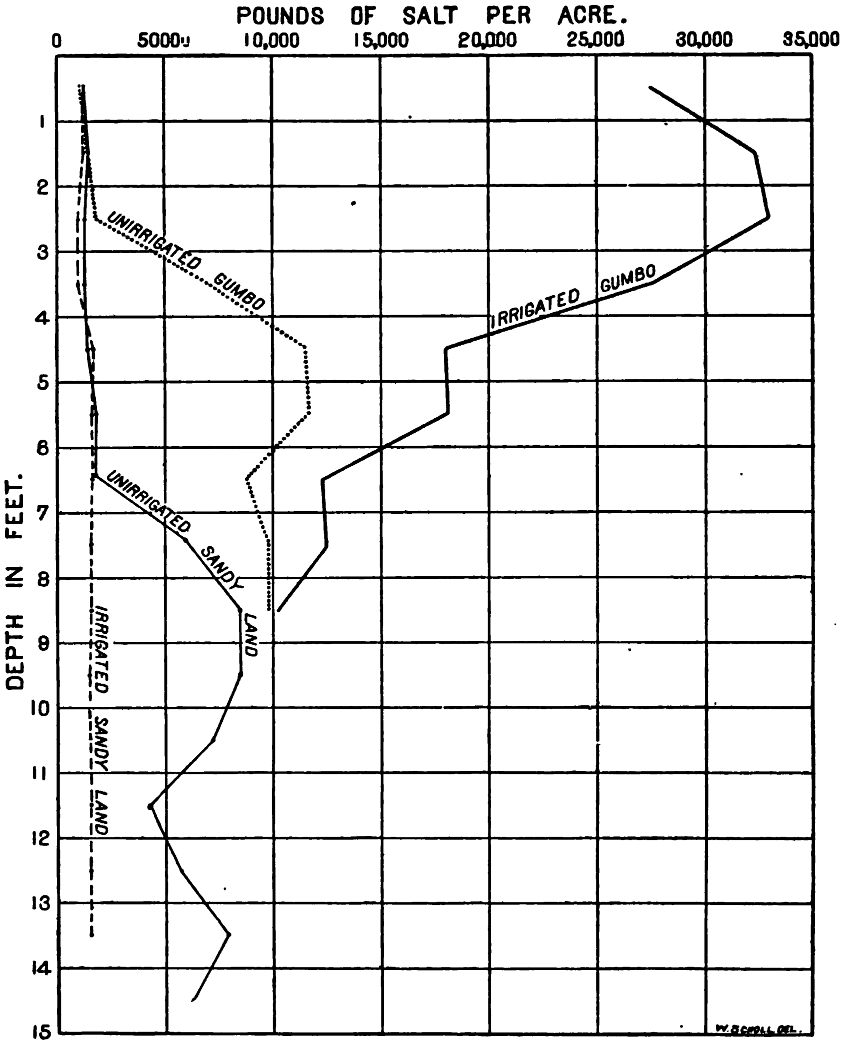

FIG. 1.—The salt content of sandy land and gumbo, with and without irrigation.

In boring 49, which was in the midst of the alkali flat, there was an excessive accumulation of alkali, beyond the limit of any agricultural plant, at least to a depth of 7 or 8 feet. Below this it rather looks as though the amount of salts was diminishing and that if the boring could have been carried deeper the salt content would perhaps have grown less. At the present time the soil in boring 52 does not contain an excessive amount of alkali for alfalfa, but the level of standing water is so near the surface that the roots of the plants are submerged and the crop can not be successfully grown. This is the first stage in the ruin and devastation that is being wrought, and boring 49 shows the final and complete stage when the land is given up to water and alkali.

When land is in the condition of boring 52, and before any notable accumulation of crust has appeared upon the surface, the land becomes covered with a heavy growth of weeds. All agricultural crops have ceased to grow for some time, and the land has been abandoned as a barren waste. Such a condition as is shown by the growth of weeds is usually thought to mean that the alkali is disappearing or is being used up by the weeds themselves, and that the soil is again becoming fit for crops. In some cases this may be true, if there is sufficient drainage to carry off the excess of seepage waters and time enough be allowed for them to move on; but in many cases the conditions simply indicate that the weeds are a class of plants which can thrive on wet ground and grow for a while luxuriantly. If the methods of irrigation are kept up and the seepage waters continue to collect and evaporate for a few years longer, alkali will accumulate in sufficient quantities to kill even the growth of weeds, and the land will truly present the appearance of a desert.

From all the facts thus far observed it can be said that the first harmful effect of overirrigation in these soils is caused by excess of water, and if this is not immediately removed further damage will result from the accumulation of soluble salts. If the excess of water is soon removed no permanent damage will result.

A line of borings was run from the center of this alkali flat for a mile and a half back to the main canal. A number of borings were made to a considerable depth and salt determinations made for every foot in depth in each of these borings. It was found that adjoining the canal and for two-thirds of the way down to the alkali flat there is but little alkali, as though the irrigation water had removed the salts from this portion of the land and that they had then accumulated in the alkali flat, which is at a somewhat lower level. These irrigation waters slowly seep through the underground channels down into the natural drainage system, which is represented in this case by the alkali flat on account of its somewhat depressed condition. The water first appears in these low places in the line of underdrainage, and as the evaporation of the water goes on the salts accumulate, gradually extending up and enlarging the alkali flats as the water rises until the level of the surrounding area is reached, when the whole district is abandoned. The area around the alkali flat is first-class alfalfa land

and the property is considered very valuable, but only three or four years ago the alkali flat itself was considered just as valuable, and the alarming feature of the whole thing is that the owners know that if these conditions continue the alfalfa field itself will be ruined and will have to be abandoned in a few years unless very energetic means are taken to arrest the progress of the trouble.

The chances are, of course, that this condition has not arisen from the local application of water at this place. It is possibly a result of injudicious methods of irrigation on the adjoining lands at higher levels. One of the most discouraging features of the whole problem is that the owner of such a tract of land may use the most approved methods of irrigation and yet be completely ruined by the excessive and injudicious use of water by his neighbor. This neighbor may escape the injurious effects of his own crude methods, at least for many years after the other has been ruined. In the contemplation of such a problem as is presented in the Yellowstone Valley, therefore, there are certain property rights that may easily be abused, causing very disastrous results to appear upon a neighbor's land. It makes the whole problem very hard to deal with, especially as it would be extremely difficult to show the source of the trouble and to locate the offending person. It is a problem, however, which will have to be taken up; and if the property owners do not themselves take adequate care of their drainage systems and use intelligent methods of irrigation some means must be found of compelling them to do so or to give redress to their unfortunate neighbors.

This accumulation of salts is very harmful in the puddling effect on the soil. The flocculation of the soil grains is broken up and the grains are separated out into their most uniform position, where they offer the greatest possible resistance to the flow of water. This puddling can be relieved only by draining off the water and the salts, and this drainage is rendered difficult by their presence, so that the reclamation of these alkali flats on the gumbo soil is an exceedingly difficult, slow, and expensive undertaking.

The formation of these alkali flats is in a way an evidence of the effort of nature to correct the faults of our crude system of irrigation. The salts are being carried off into the natural drainage of the country, but the process is very slow and the excess of seepage water and the salts themselves collect in these places on account of the inability of the soil to let them pass as rapidly as the excess of water is supplied. This suggests the only feasible method of reclaiming these lands and, indeed, of preventing the accumulation of the salts which will occur except under the most careful and judicious methods of applying water. In cases like that under consideration, where the damage has already been done, the natural drainage is so slow that it does not afford adequate relief, and in fact is but a sign of impending ruin for a very much larger area. The only way to reclaim the land is to put in an efficient system of drains, preferably of underground tile drains. It is urged against this idea that the land is not worth the cost of the investment in putting in a system of tile drains. This, of course, is an economic problem which is entirely dependent upon conditions of market, transportation facilities, and other commercial considerations. It may or may not be profitable at this time to protect the lands from destruction and to reclaim those that have been destroyed. It may be cheaper to move off into new areas, but the time will come, if it has not already come, when the land in the Yellowstone Valley and in similar situations will be worth the care and expense necessary to protect it from ultimate destruction. The amount of money now invested in the Yellowstone Valley is enormous, and the continuance of prosperity is entirely dependent upon the care which is taken in the methods of irrigating the lands. Property worth thousands of dollars may be ruined in a few years and become utterly worthless. The experience in the valley shows that this has been the case in the past, and there is much uneasiness felt in regard to large areas which show signs of the rapid spread of alkali.

EFFECT OF UNDERDRAINAGE IN REMOVING SALT.

There is abundant evidence that thorough underdrainage will reclaim these lands, and if introduced in time will prevent any such disastrous results as those which have been described. There has been no thorough system of tile drainage tried, but a few efforts have been made to reclaim the abandoned lands by open drains. That these have been efficacious the following investigations will show:

A drainage ditch had been dug in the alkali flat on section 2, T. 1 S., R. 25 E., and the excess of water had been continuously removed for some time before this investigation was made. A line of borings was made from this ditch back about one-fourth mile to see how the salt content had been changed. The results are given in the accompanying table, which represents the per cent of soluble salt found at different distances from this ditch.

Salt determinations at different distances from a drainage ditch.

Depth (feet).	Boring 45.	Boring 46.	Boring 47.	Boring 48.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
0–1	0.047	0.054	0.155	0.419
1–2	.030	.066	.164	.258
2–3	.036	.112	.177	.257
3–4	.031	.103	.213	.238
4–5	.045	.109	.191	.275
5–6	.045	.120	.191	.267
6–7	.043	.138	.225	.275
7–8	.043	.162	.237	.337
Average	.040	.108	.194	.290
Total pounds per acre 8 feet deep.	11,200	30,280	54,320	81,200

Boring 46 shows the amount of salt about 300 yards from the drainage ditch. The next column shows the amount at about 100 yards from the ditch, while the last column shows the amount closely adjoining the ditch. It will be seen from this table how the salts have accumulated at the lowest point of the drainage system and how they are being removed by the drain as the water from the irrigating ditch seeps down and the excess of seepage water is carried off. The amount of salt found at the drainage ditch is already below the 15,000 pounds limit of crop production, while farther out in the alkali flat, under presumably the same conditions as existed at the drainage ditch when it was cut, the amount of salt is upward of 35,000 pounds per acre-foot.

It is easy to show in another way the beneficial effects of underdrainage. The land around Billings is underlaid at a depth of from 6 to 8 feet by a layer of gravel. Within the last few years it has been necessary to construct a ditch around the town of Billings to cut off from the town the seepage waters from the irrigated lands. This ditch is cut to a depth of 6 or 8 feet, so that it is in the gravel through its whole length, and it receives the water from two or three natural draws and all of the seepage water from four or five sections of land. No sewerage is allowed to flow into the ditch from the town.

A number of observations were made upon this ditch during the month of June. It was estimated that the average flow of water during this time was about 40 cubic feet per second. Frequent determinations were also made of the soluble salt content of the water flowing in this drainage ditch.

The following table gives the amount of salt found during the month of June:

Examination of drainage water.

	Salt (per cent).	Tons of salt removed per hour.
June 4	0.302	13.6
June 6	.424	19.1
June 7	.422	19.0
June 11	.449	20.2
June 12	.283	12.7
June 13	.481	21.6
June 16	.227	10.2
Average	.370	16.6

It will be seen that the ditch is doing a great work in removing the salt content from the overirrigated lands around the town. At the rate at which the salt was being removed at the time these observations were made the ditch was removing about 16½ tons per hour. If this rate was continuous it would drain 1 per cent of salt from the upper 5 feet of about 900 acres of land per year. As a matter of fact, while the ditch rarely if ever stops flowing, the flow is not always as great as during the time of this investigation. Still, the figures give some idea of the enormous results which may be accomplished by a judicious system of drainage in the reclamation of these alkali lands and the protection from an undue accumulation of salt and seepage waters.

It may be well to state that the water in the main irrigating canal that is taken out of the Yellowstone River about 40 miles above Billings, although carried for this great distance through the valley, was fresh and free from salts. From all sources, however, where this water was escaping as seepage water it is seen to be loaded with excess of salts, and where free to flow off readily the salts will be carried off instead of accumulating in the alkali flats.

Besides the examination of the drainage ditch around the town of Billings many determinations were made of the salt content of springs and wells. The following table gives the determinations of the salt content from a number of places.

Salt content of springs and wells near Billings.

	Per cent.
Spring on the sandstone bluff	.029
Well on west side of sec. 2, T. 1 S., R. 25 E	.119
Spring on west side of sec. 2, T. 1 S., R. 25 E	.212
Well on north side of sec. 2, T. 1 S., R. 25 E	.309
Spring on north side of sec. 6, T. 1 S., R. 26 E	.433
Spring in center of sec. 5, T. 1 S., R. 26 E	.437
Well on south side of sec. 1, T. 1 S., R. 25 E	.536
Well on north side of sec. 2, T. 1 S., R. 25 E	.538

Well water containing more than one-tenth of 1 per cent is ordinarily considered unfit for domestic use. In most of these wells the water was less than 5 feet below the surface of the ground, and the water tasted strongly saline.

It will be seen, therefore, from all of these sources that the water in the soil is charged with this excess of salt. If there is a ready means provided for it to leave the soil, there will be no excess of soluble salts. It would, of course, be unfortunate to depend upon this to carry off the salts from reckless overirrigation, for in removing these salts much valuable plant food may also be lost and the soil in a measure impoverished. It is necessary, therefore, even with a system of efficient underdrainage, to use great care, so that there shall not be more loss through underdrainage than is necessary. It is perfectly evident, however, on the other hand, that if these conditions continue and the water rises closer to the surface than it is at present, that the seepage waters and the accumulation of salts together are likely to prove very disastrous over larger areas.

Many theories have been advanced by the land owners around Billings, and in these other localities also, as to the source of the alkali and as to the conditions under the surface. The belief is widespread that the alkali flats can probably be reclaimed by flooding the surface during a dry season and washing off the crust. Investigations, however, have shown very conclusively that the crust contains only a very small proportion of the alkali, and that this method alone will not be sufficient to remove the trouble. Many of the planters are beginning to see that the rise of alkali is coincident with the accumulation of seepage waters, and to realize that the trouble is probably due to a too lavish use of water in irrigation.

Hilgard has pointed out for years that the only safe practice in bringing a new area under the ditch, in a soil that is at all likely to have alkali, is to use water very sparingly and keep the land under thorough cultivation, so that a minimum amount of water shall evaporate from the surface of the ground to deposit the salts, and so that there shall be no accumulation of seepage waters in the subsoil.

Hilgard has repeatedly called attention to the reactions between lime salts and the salts of the alkalies.

Where sodium or potassium carbonates or chlorides are associated with calcium sulphate in a well-aerated soil, a reaction takes place in which sodium or potassium sulphate and calcium chloride or carbonate are formed. The calcium chloride is extremely soluble and easily leached from the soil if there is any chance at all of its being carried off by drainage waters. The calcium carbonate is difficultly soluble and would remain in the soil as limestone. On the other hand, where sodium or potassium sulphate exists in the soil, together with lime carbonate and in the presence of an excess of carbonic acid or in the presence of supercarbonates of the alkalies, the reverse action takes place and carbonate of soda or potash is formed, together with the sulphate of lime.

Hilgard shows this reaction actually taking place in certain conditions of the soil. He points out that the carbonate of soda and sulphate of lime may occur in the bottom of a slight depression where the soil is moist, while the sodium sulphate and calcium carbonate will be found around the edges where the soil is better drained. As a practical application of this knowledge, he urges the use of gypsum or sulphate of lime in the reclaiming of lands containing the black alkali or carbonate of soda, and at the same time points out the necessity of thorough drainage in connection with the application of gypsum; otherwise the application will do no good at all.

These various reactions and properties of the so-called alkali salts indicate the methods for the reclamation of the alkali lands. In the case of the carbonates the course recommended by Hilgard is unquestionably the proper one—to treat the soil with heavy applications of gypsum and insure thorough drainage, so as to have the soil well aerated. In the case of an excess of sodium chloride, which is very soluble and easily leached out of a soil, it is only necessary to flood the soil and remove the excess of salt in this way. It is essential, however, that the soil so treated should have good underdrainage in order that the water applied at the surface may percolate through and actually carry off the excessive amount of the soluble sodium chloride. No application of any kind will be beneficial, as the sodium chloride is as simple a salt as one can have and quite harmless, except when present in extraordinary amounts.

The treatment of soils containing sodium sulphate is more difficult than in the case of the chloride, as the salt is less easily leached from the soil. Here, again, no application, however, can be made, the sulphate, like the chloride, being injurious only when in large excess. It will be shown further on that the surest plan in the cultivation of these alkali soils is to use care in applying the water, so that there shall be no accumulation of the salts at the surface, and, as Hilgard has repeatedly recommended, the cultivation should be very thorough so as to prevent, so far as possible, the evaporation of the water from the surface of the ground. When the salts have once accumulated, however, there is nothing to do but wait for them to gradually leach away through the drainage and seepage waters or to thoroughly underdrain the land with tile drains, and so hasten the reclamation.

SUMMARY OF THE INVESTIGATIONS AND CONCLUSIONS.

The results of these investigations show that there is no sodium carbonate or black alkali in the soil. The source of the alkali is in the sandstone, and particularly in the shale or slate rocks from which the soils have been derived. Before irrigation was introduced the salts were present in the soils in rather large amounts, but well distributed, and not in such large quantities as to be injurious to crops. The injury is due entirely to overirrigation, to the translocation and local accumulation of salts by means of seepage waters, and to the imperfect drainage facilities in the compact gumbo soils and the inability of the excess of salts and of seepage waters to escape. The first trouble appears to be due to the seepage waters. This, of course, need not necessarily be so, but it appears to be the case in this locality. The open, sandy lands, having better underdrainage, are not likely to be injured by a rise of salts except from an excessive application of water or in the low places in the path of the drainage system, especially when these are underlaid, as they are liable to be, by the heavy gumbo subsoils. The gumbo soil requires great care in cultivation, as it is easily ruined by the accumulation of seepage waters and the subsequent accumulation of salts. There are many areas in the valley, of course, which have still a low or moderate salt content which are probably safe for years to come. There are other areas in which the salts are now accumulating to such an extent as to render the future value of the land very uncertain, while there are still other areas which have gone beyond this stage, and what were once fertile tracts have been thrown out as barren flats. The investigations show, further, the very disturbing fact that the injury need not be due to a local application of water, but to the injudicious application of large quantities of it in remote localities and on neighboring farms over which the unfortunate person has no control and for the effects of which he has, at present, no redress.

The investigations point clearly to the natural methods of preventing this injury and of reclaiming the lands when once the injury has occurred. There is no question that the injury is due to the translocation and local accumulation of the salts which were formerly well distributed in the soils of the valley. Alkali has been troublesome here only after eight or ten years of irrigation. The trouble is always preceded by an accumulation of seepage waters, followed in a few years by the alkali incrustations on the surface of the land. This evidently points to the necessity of great care in the application of water in the methods of irrigation. This care must be exercised not only for the land which is being irrigated, but for the adjoining lands on lower levels. While a man can overirrigate a sandy tract with practical impunity to himself, he is likely to swamp his neighbor on a lower level. There are involved property rights, therefore, which will come to be recognized and which will have to be taken into consideration in any intelligent and safe system of irrigation.

Where the damage has been done, or where the conditions are so imminent that ultimate ruin can be foreseen, the logical method of reclamation is in providing adequate systems of drainage to carry off the excess of water and the accumulated salts. This is expensive, but it is the only thing in this case to hasten the slow processes of nature, which are entirely inadequate in the presence of the present methods of irrigation and of culture. Underdrainage is expensive, but it has amply repaid for the investment in other localities where land is worth no more than in the Yellowstone Valley. Any land which is worth $50 per acre could well afford to be taxed for underdrainage if it is necessary, as in many places in the Yellowstone Valley, to save the investment from utter annihilation. It may be too soon yet to urge an extensive system of underdrainage in the valley, but some small systems should certainly be introduced, if necessary by cooperation, for an object lesson when it is considered necessary and timely to protect against trouble or to reclaim lands already abandoned. The owners will then see that it is feasible to protect their lands and to reclaim, through underdrainage, those that are abandoned.

It has been pointed out already that there are some crops which can stand much larger percentages of alkali than others. It is quite possible that other valuable crops can be found or can be bred which will stand large quantities of alkali, but it is unfortunate, indeed, for a locality like the Yellowstone Valley, which was originally free from alkali, to accept such conditions resulting from their injudicious methods of irrigation and try to find crops which will thrive upon lands which have been unnecessarily injured.

It must not be assumed, however, that a thorough system of underdrainage relieves one from exercising care and judgment in applying water to the land. There is less immediate danger of ruining the land, to be sure, but there are two things to be considered, namely, that an excessive use of water means just so much loss to irrigation and so much less land which can be brought under the ditch, and also that in the removal of these salts by the flow of the seepage waters out through the drainage system large quantities of really valuable plant food are likely to be removed from the soil. The very accumulation of these soluble salts is due to the arid conditions of the climate. The great fertility of the soil results from the accumulation of these salts, and if we introduce artificial drainage, which will tax the resources of the soil, we may remove in the course of a generation, or even in less time than this, the accumulated results of the changes of vast geologic ages in the disintegration of rocks. By overirrigation and underdrainage we may remove in a few years the very conditions which contribute to the wealth of the country in the fertility of the soil.

In taking up new land in the Yellowstone Valley the heavy gumbo soils should be underdrained at the time the first irrigation waters are applied to the land. Even if the system of underdrainage is not complete at the start, a sufficient amount of it should be put in to answer the purpose at the beginning, and so arranged that it can be extended and more laterals put in as time goes on and the necessity of it becomes apparent. It is too late to wait until the damage has been done, for the accumulation of salts themselves acts on the heavy gumbo soils and makes them more impervious to water and harder subsequently to drain. Great care must be taken in the application of water. As little as possible should be applied at each time, so that there shall be as little waste as possible to go off as seepage water. The surface then should be thoroughly cultivated, unless otherwise protected from evaporation by alfalfa or other close-growing crops, so as to reduce the loss of water from the surface to a minimum and prevent thereby the accumulation of salts at the surface.

The rise in the level of water in wells must be looked upon with uneasiness and guarded against with great care.

The conditions in the Yellowstone Valley are particularly simple, and the danger from the rise of salts may be easily controlled. These investigations show the cause of the trouble, the actual conditions over a small section of the valley, and point out the logical methods of preventing trouble and of redeeming the land after the trouble has come. The locality is fortunate indeed in having no great excess of alkali in the soils previous to irrigation, as occurs over such large areas in adjoining States. The question involved is a simple problem, well within the control of the intelligent land owners of the valley.

While the discussion of this important subject in the present publication has been confined to the Yellowstone Valley, it is nevertheless one, as already stated in the introduction, of practical interest all through the States of the far West, and the principles applicable in the case under discussion are in general applicable to alkali lands throughout the country.

FARMERS' BULLETINS.

These bulletins are sent free of charge to any address upon application to the Secretary of Agriculture, Washington, D. C. Only the following are available for distribution:

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Agros. 38.

U. S. DEPARTMENT OF AGRICULTURE.

FARMERS' BULLETIN No. 89.

COWPEAS.

BY

JARED G. SMITH,
ASSISTANT AGROSTOLOGIST

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LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
DIVISION OF AGROSTOLOGY,
Washington, D. C., January 19, 1899.

SIR: I have the honor to transmit herewith, for publication as a Farmers' Bulletin, a paper by Mr. Jared G. Smith, assistant agrostologist, entitled Cowpeas.

The necessity for the more extended cultivation of grasses and forage plants in the Southern States is very great. The Southern farmer must not confine himself to the growing of cotton, cane, or tobacco, but should adopt modern methods of diversified farming. There must be pasture lands and hay meadows on every farm in order to feed the cattle, sheep, and swine, the purchase of which in the form of meat products now consumes the profits from the cash crops of cotton, rice, cane, and tobacco. There is no better forage plant or soil renovator than the cowpea, in some of its numerous varieties, because of its adaptability to the wide range of soils and conditions.

Respectfully,

F. LAMSON-SCRIBNER,
Agrostologist.

HON. JAMES WILSON,
Secretary of Agriculture.

CONTENTS.

Page.
Introduction 5
The cowpea 5
    Varieties 7
Cowpeas and soil renovation 8
Cowpeas for forage 9
Methods of cultivation and harvesting 10
Cowpeas for swine and cattle 12
Cowpeas for silage 12
Harvesting the seed 13
The feeding value of cowpeas 14
Fertilizers 15

ILLUSTRATION.

FIG. 1. Leaf and pods of the cowpea (*Vigna catjang*) 6

COWPEAS.

INTRODUCTION.

Thousands of tons of hay from the Northern and Western States are each year marketed in the South. Many of the Southern farmers and planters still hold to the methods of thirty years ago, growing a main crop of cotton, cane, or tobacco, and buying meat products and forage instead of producing these on the home estate. This is no longer profitable because of the low prices to which the staple crops have fallen, and there is no valid excuse for the continuance of this practice. The South has as great an abundance of grasses and leguminous forage plants as any other section. While red clover and timothy can not be depended on, there are other hay crops just as reliable for the South as these excellent grasses are for the North. There is perhaps greater need for the cultivation of leguminous crops in the South than in the North. The soils are more liable to the rapid exhaustion of the available plant foods, because the leaching of soluble salts goes on all the year. Following the prodigal methods of the past, the farmer depends on annual applications of commercial fertilizers to repair the waste. Soils can be most profitably built up by increasing the amount of organic matter in them, and the quickest and cheapest way of doing this is by growing leguminous forage crops and feeding them on the estate, returning all the manure to the land. Alfalfa, cowpeas, velvet bean, Florida beggar-weed, melilotus, Japan clover, and winter and hairy vetches may all be grown. These forage crops supplemented by cotton-seed meal and hulls will provide the best forage for work stock, cattle, sheep, and swine, enriching the plantations and the planter, adding nitrogen and humus to the soil, replacing the more expensive commercial fertilizers and providing hay as good as any that can be bought in any market.

THE COWPEA.

The cowpea (fig. 1) is to the South what alfalfa is to the West and red clover to the North—a forage plant well adapted to the needs of the region. The cowpea has been cultivated in the South for at least one hundred and fifty years. It was probably first introduced on plantations in South Carolina, the seed having been brought from India or China. From this original introduction and from subsequent importations its cultivation has spread to almost every farm and plantation in the Southern States.

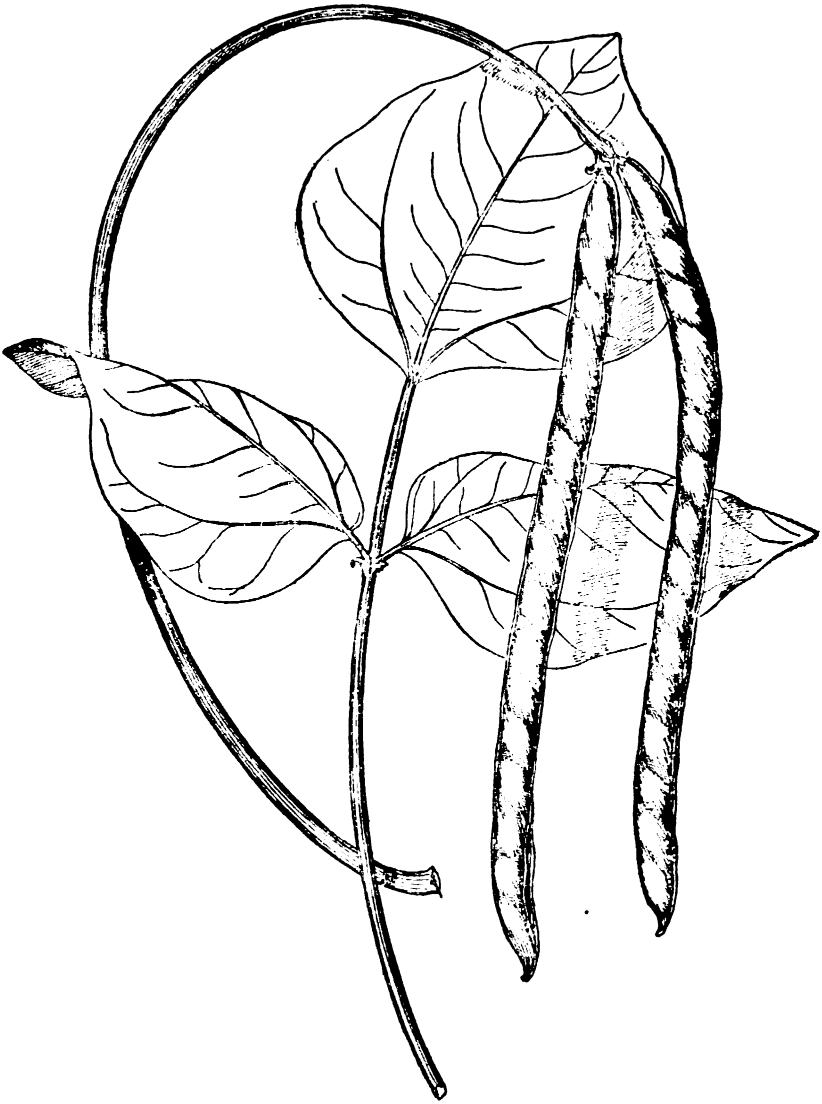

FIG. 1.—Leaf and pods of the cowpea (*Vigna catjang*).

Cowpeas are in their relationship and habit of growth really beans and not peas, as the name would indicate. They are annuals, belonging to the genus Vigna, the members of which are largely represented in South Africa, and are closely related to the lablab, lima, and haricot beans of our gardens, as well as to numerous cultivated or half-wild garden sorts common in tropical Asia and America, but little known to us.

VARIETIES.

There are a very large number of named varieties of this forage plant. New forms are constantly arising, due to variations in the habit of growth, color of leaf, stem, and pod, and the shape and color of the seed. Variations from any chosen type are constantly appearing, and as one or another of these sports or forms gains sufficient local reputation a new name is applied, and sooner or later the supposed new variety is placed upon the market. In this way one variety of cowpea may be cultivated in a dozen different localities under as many names, or a dozen different peas may bear the same name.

Cowpeas occur in every gradation of habit, from a compact, stocky, upright bush having single stems a foot high with very short lateral branches, to those with trailing runners growing as flat upon the ground as sweet-potato or melon vines, the prostrate stems 15 to 20 feet in length. The pods vary from 4 to 16 inches in length, and the peas are of every imaginable shade of white, yellow, green, pink, gray, brown, red, purple, and black, of solid colors or variously mottled and speckled, and of varying sizes and forms, from large kidney-shaped to little round ones smaller than the garden pea. There is a like variation in the length of time the different forms require to ripen seed, some requiring eight or nine months, a few ripening in sixty days from the time of planting.

There seems to be a somewhat constant relation between the time required for attaining maturity and the habit of growth. The bush varieties ripen in a shorter season than the trailers, but a bush variety taken from Tennessee or Virginia will, in the course of a few seasons, assume the trailing habit, and lengthen out its period of growth, when removed to the Gulf States. Also, a runner or creeper requiring six to eight months for reaching maturity in Louisiana will, if planted each year a hundred miles farther north, gradually accommodate itself to the shorter season and at the same time shorten its runners, approaching more and more to the upright or "bush" habit of growth. No definite line of separation can be drawn between bush peas, trailers, and runners. The best varietal character is probably the color of the seed. It is quite probable that more than one species is in cultivation. The "red" and "black" varieties are closely allied; the round "lady" peas form a separate group; the large "black-eyed" and "purple-eyed" are typical of another, and the variously mottled and speckled "whip-poor-wills" are only a degree removed from the solid-colored yellow, pinkish, and light-brown ones, and together would naturally be taken to constitute one species or variety. The black peas pass through various shades of red before maturity. The red varieties sometimes carry their change of color in ripening so far that they can not be distinguished from the black. The "black-eye" and "purple-eye" are of the same ground color, differing only in the color of the ring surrounding the eye. The various "crowders," yellow and white, the whip-poor-will, clay, and "yellow-eye" forms have numerous crosses and so-called hybrids in which the fundamental yellows and browns form varying mixtures.

COWPEAS AND SOIL RENOVATION.

A field of cowpeas has been very happily designated "the poor man's bank," for in common with all its leguminous congeners, the field pea, clovers, alfalfa, and a score of others, this crop increases the fertility of the soil upon which it grows. This fact has long been accepted by farmers and students of agriculture, but until recent discoveries in Germany and America it was believed that the chief function of these plants was to tap the subsoil reservoirs of nitrogen, bringing this valuable fertilizer to the surface by means of their long roots for the use and benefit of succeeding crops.

But within the last decade scientific workers have discovered that minute micro-organisms, or bacteria, which live within the tissues of the roots of leguminous plants, take up free nitrogen from the gases in the soil, just as the higher plants and animals utilize the oxygen of the air. This nitrogen enters into combination to form nitric acid, which unites with the mineral elements of the soil to form nitrates, a kind of plant food exceedingly valuable to the growing crop. Nitrogen, when in combination with other elements, is an indispensable form of plant and animal food, but the free element can not be utilized, uncombined, by any of the higher organisms. Small amounts of nitrous acid are formed in the air by lightning discharges, and are in part absorbed by the soil and in part carried by rivers and drainage waters into the sea. Free nitrogen exists only in the air and in the gases of the soil, but as ammonia, nitrous and nitric acid, nitrites and nitrates, it is present in varying quantities in the soil, the unbroken rocks, and the waters of continents and oceans.

The most available purchasable nitrogen is obtained from nitrate of soda or from some form of animal wastes, such as freshly ground bone, dried blood, guano, tankage, and fish scrap, and from cotton-seed meal and other like by-products of the oil mills. These fertilizers are all expensive, so much so that they can be profitably employed by the farmer only in intensive farming with specialized crops. The gain in yield with low-priced crops, such as corn, cotton, tobacco, cowpeas, and the grasses, using high-grade and costly fertilizers, is not commensurate with the additional expense. But every farmer, rich and poor, has over three thousand tons of atmospheric nitrogen resting on every acre of his farm, a certain quantity of which can be transformed into available plant food every time that he grows a crop of cowpeas, red clover, or alfalfa.

There are a great many acres of farming land in the South in need of renovation. The red uplands and yellow-clay soils were undoubtedly less fertile originally than the alluvial and black prairie soils, and the methods of cultivation which formerly prevailed have still further diminished their productiveness. In the days when every plantation numbered its acres by the thousand, and labor was cheap, the planter could afford to clear off the native forest growth and bring fresh fields into cultivation whenever the yields of cotton and tobacco fell below what was considered a profitable figure. The old field, stripped in a few years of its accumulated store of fertility, was abandoned and allowed to grow up to weeds and underbrush. The forest again spread across it, and gradually, in the slow course of half a lifetime, the natural enrichment of its surface soil by the growth of the woodland grasses made it ready for another cultivation.

But with the breaking up of the large estates and the abrupt change in the labor conditions this method of farming became no longer profitable or even possible. A planter with fewer acres could no longer afford to await nature's slow process of rejuvenating the soil. A new system of farming was necessary. The land must not be allowed to "go back." It must be kept up to the highest state of productiveness by a rotation of crops, a judicious use of commercial fertilizers, the growth of nitrogen-fixing leguminous crops, and good and thorough cultivation. To maintain the fertility of any soil the amount of humus or decaying organic matter in it must be maintained. Take two soils of as nearly as possible the same physical and geological formation, but the one rich in humus and the other lacking it, and fertilize them with equal quantities of commercial manures; the one which has the most organic matter in its composition will yield the larger crop. The soil on that field will stand drought better, will wash less under torrential rains, and be more friable and of better tilth. The average soils of the South need more humus. It can be best supplied by sowing more grass, more permanent pasture lands, more leguminous crops. In a word, plant cowpeas.

COWPEAS FOR FORAGE.

There is no forage plant better adapted to the needs and conditions of Southern agriculture than this rank, free-growing annual. It will thrive luxuriantly upon the rich, swampy, cane lands of Louisiana. On the driest and most sterile worn-out uplands it serves the admirable purpose of supplying a larger quantity and better quality of forage than any other bean or clover. And whenever a crop of cowpeas has been taken off a field the surface soil is left richer by a good many pounds of that most costly of all plant foods, nitrogen. The roots of the cowpea enter deeply into the soil, opening and loosening it far down for the benefit of the roots of the succeeding crops of corn, cotton, and tobacco. It has been found by experiment that the fertilizing value of the roots and stubble of the cowpea are very considerable, but not as great as that of the hay removed from the field. The best and most economical use of this forage crop is, then, to cut for hay, feed to stock, and return the stable manure to the soil. Plowing the whole crop under is less remunerative, because there is much needless waste of the muscle-making and fat-forming constituents of the plant which would bring more profit if turned into beef, pork, wool, cheese, or butter.

As regards the disposal of the crop, there is a wide variation in practice. The feeding value of vines and peas much exceeds their fertilizing value. But as between the practice of turning the vines under green in autumn and that of allowing them to lie on the ground during the winter, the latter is undoubtedly sometimes to be preferred, though theoretically wrong. Theoretically, to plow the vines under in autumn will be to save all the available nitrogen and convert the whole plant into humus. Practically, the turning under of so large an amount of watery green herbage is sometimes highly injurious, causing a too rapid decay and consequent "burning" or souring of the soil. The upper soil layers, freshly stirred and mellowed in autumn, lose more by leaching and washing than do those of an unplowed field covered by its winter mulch of decaying herbage, though in both cases there is a decided loss of fertility over what would result by following the peas with a crop of rye, winter wheat, the turf-forming winter oats, winter vetch, or crimson clover. The yields of forage are better on rich soils than on poor ones, but the beneficial effects upon the succeeding crop due to the growth of the cowpea are not so marked in the former case as in the latter.

METHODS OF CULTIVATION AND HARVESTING.

Cowpeas are planted broadcast or in drills, very commonly between the corn rows after the crop is laid by. The amount of seed used varies from 4 quarts to 2 bushels per acre, the average amount being, perhaps, about 3 pecks. If sown in drills, 18 to 30 inches apart, less seed is required than when sown broadcast. The seed will stand being covered to the depth of 2 or 3 inches, but care must be taken to plant when the ground is neither too wet nor too cold, as the peas rot very rapidly under such circumstances. In regard to excess of moisture cowpeas behave like beans, and in the early stages delight in a warm, mellow seed bed. Much of the failure that has attended the attempted introduction of cowpeas into the Northern States is due to planting before the ground is warm enough. It must be remembered that this plant originated in the Tropics and that when transplanted to higher latitudes it makes its best growth in the hottest weather. It is even more susceptible to cold and wet than is corn. Hence, proper delay in planting will permit economy in the use of seed. Where the vines are grown for hay, the yield will be larger if the seed is planted in drills and cultivated a time or two. The yield of peas is also larger when only a moderate amount of seed is sown and the vines have more space and light and air between them. It is also heavier from late-planted vines than from the very early ones. In tests to determine the relative value of different named varieties it has been found that, as a rule, those which make the heaviest yields of vines also bear large crops of peas.

The vines should be mowed for hay when the peas are well formed and the leaves and pods are first beginning to turn yellow. After wilting on the ground or in windrows from twenty-four to forty-eight hours, the hay is placed in small, thin piles, or cocks, and allowed to cure for several days, when it may be carted to the barn or stacked under sheds. The haymaking process is a difficult one, requiring more care and attention than in the case of red clover, because the broad leaves and thick stems contain a larger amount of water. The hay must be placed in cocks before the leaves become brittle, and the piles must be small enough to allow free circulation of air to the center of each. Bright cowpea hay, clean and well cured, is worth as much as the best red-clover hay, and there is no good reason why the Southern farmers and planters should buy the Northern-grown article for their working stock or for fattening their cattle. Every ton of hay used on the farm should be grown there. Another method of curing hay is to stack the vines in a pen or rack of rails or poles so arranged as to allow the air to enter every part of the pile. This stacking over poles is best where the vines are pulled, or where the trailing and creeping sorts are used. The bush varieties are the best for hay, because of the greater ease with which they may be mowed and handled. They also hold their leaves better than the ranker trailing sorts. The yield of hay varies according to the fertility of the soil upon which it is raised, whether it is grown on rich lowlands or on the drier and more sterile uplands. In the Gulf States cowpeas will probably give an average yield of 2 to 3 tons per acre, while 4 to 6 tons are not uncommon. Farther north the average will range from 1½ tons in Ohio to 2½ tons in Arkansas, Missouri, and Tennessee. As with other crops, the time of planting, the character of the soil and of the cultivation, and the amount of rainfall have much to do with the yield. Along the Gulf it is one of the best hay crops. North of the latitude of the Ohio River it is chiefly valuable as an addition to the list of drought-resistant, soiling crops and as a crop that will yield a considerable amount of forage on soil too sterile to grow red clover. The commercial value runs from $6 to $20 per ton, being governed by the relative abundance of other grades of hay and fodder. Its feeding value is equal to that of the best red clover, and the hay ranks high in palatability and digestibility.

COWPEAS FOR SWINE AND CATTLE.

When cowpeas are planted for green manure, it is an excellent practice to turn hogs into the field about the time that the first peas are ripening. Young pigs thrive amazingly on the succulent foliage and well-filled pods, and the quality of the pork raised on such a healthful and nutritious diet is very fine. This is a profitable method of fattening hogs or of preparing them for topping off with corn or sorghum for market. An acre of ripening cowpeas will pasture from fifteen to twenty hogs for several weeks, and the gain in fertility from the droppings of the animals during that period will more than counterbalance the fertilizing value of the forage eaten. The rapid increase in weight will thus represent so much clear profit, and the farmer is richer by half a ton or more of prime pork for every acre planted. Chickens and turkeys also eat the ripe peas and do well upon them. Cattle and horses are sometimes pastured on them, but the safer and more economical way of feeding the green cowpea vines to such stock is to cut or pull and feed partially wilted. There will be less waste and destruction from trampling, and if each animal is given only so much as it can eat clean, the greatest economy as well as greatest profit will result. Furthermore, cattle and sheep are liable to bloat if allowed to eat too ravenously of cowpea vines or any other rich and succulent forage, and by using it as a soiling crop the danger may be more readily controlled and the loss prevented. The report has been sent out from some of the Northern experiment stations, where this forage plant is not ordinarily cultivated, that cattle will not eat the green vines except after having been starved to it, and then only sparingly. We have seen Western horses and ponies that would not touch red clover or a grain ration of oats, and Eastern stock that would not eat alfalfa hay. But these few adverse cases do not prove that red clover, alfalfa, and oats are not good forage. With the cowpea the case is similar. It is very rarely that any Southern planter reports that this forage is refused by any kind of stock.

COWPEAS FOR SILAGE.

Reports are very conflicting in regard to the value of this crop for silage. There is much positive testimony both for and against, some authorities stating that the quality is excellent and others that the vines contain too much water, the product of the fermentation being a slimy, foul-smelling mass, unfit for food for any kind of animals. From reports on the subject it is to be believed that the attempt to convert cowpea vines into good silage can not be made with such uniform success as in the case of red clover. The percentage of water in the tissues is too high, and the mechanical difficulties in the way of running a mass of tangled herbage through the feed cutter are too great. Special machinery would have to be constructed for the purpose. Indian corn will probably remain for many years the best all-round forage plant for this purpose. The consensus of opinion among agricultural workers seems to be that ensilage made from any legume, whether it be cowpeas, vetches, soja beans, alfalfa, or the clovers, does not equal in feeding value good hay made from the same. Under certain conditions that arise in the silo the crude protein is converted into indigestible or insoluble nitrogenous compounds, but the losses from this cause are perhaps no greater than those that result from the careless handling of the hay in the field, stable, and feeding pen. Good cowpea or clover silage is valuable, but either corn or sorghum is far superior to it.

HARVESTING THE SEED.

The majority of farmers harvest only enough seed of cowpeas to plant again the next season. The ripe pods are picked by hand and are stored in barrels until needed or are thrashed out by machine or with flails on the barn floor during the winter. Sometimes, if the crop is heavy enough to render it profitable, the vines are run through an ordinary thrashing machine from which the concaves and alternate teeth of the cylinder have been removed. But a machine breaks and bruises more of the seed than when the pods are first picked off by hand. Fully 95 per cent of the seed placed upon the market is hand picked. The yield per acre varies according to the variety and the method of cultivation. Eight to 12 bushels is a fair average of the amount that can be obtained when the peas are planted in the corn rows. Sown alone, broadcast or in drills, yields of from 20 to 35 and even, in rare cases, 50 bushels are obtained. The Black, Unknown, Red Ripper, Clay, and Calico varieties are all heavy seed bearers. Lady and White Crowder are good for table use and also yield well. The Black-eye, Red Crowder, and Whip-poor-will, or Speckled, are very widely cultivated and find ready sale. Those which make the largest growth of vines for green manure, as a winter soil mulch, for hay or soiling are the Unknown, Red Ripper, Southdown, and Clay. Whip-poor-will, Black-eye, White, and Red Crowder ripen in from twelve to fourteen weeks, and hence are adapted to cultivation farther north than the very late, but ranker growing, Unknown, Wonderful, Red Ripper, Black, and Gourd varieties. The New Era and Lee ripen seed in from six to eight weeks, and hence are the ones to recommend for summer-soiling crops in the upper prairie region of the Mississippi Valley or anywhere else that an early maturing cowpea is required. This is one of the species of cultivated plants which is very readily modified by change of habitat. Early and late maturing forms may be found of every strain that has been in cultivation for any considerable time.

THE FEEDING VALUE OF COWPEAS.

The feeding value of cowpea hay is very high, as shown by feeding tests and chemical analyses. Berckmans states that the well-cured hay is more nutritious than any hay produced from grass, millet, or any other plant used for the purpose, and that one ton of it will last as long as a ton and a half of the best timothy. One hundred pounds of the green vines contain 16.4 pounds of total dry matter, of which 10 pounds are digestible. One hundred pounds of the hay contain 89.3 pounds of the total dry matter, of which 50.7 pounds are digestible. The digestible crude protein in the hay amounts to 10.79 pounds in comparison with 10.58 for alfalfa, 10.49 for crimson clover, 6.58 for red clover, and 2.89 for timothy. The digestible carbohydrates and fat amount to 39.91 pounds in every 100 pounds of cowpea hay, 38.71 for alfalfa, 39.42 for crimson clover, 37.01 for red clover, and 45.15 for timothy. The average nutritive ratio[*] of cowpea hay is 1:3.9; of alfalfa, 1:3.8; of crimson clover, 1:3.9; of red clover, 1:5.9; and of timothy, 1:16.2. The green cowpea vines are more succulent than red clover or any of the grasses, containing less dry matter per total weight.

The feeding value of the hay is shown by the nutritive ratio which represents the relation of the digestible crude protein to the carbohydrates and extract matter. Thus, for every pound of digestible crude protein in cowpea hay there are 3.9 pounds of digestible carbohydrates and fat. In order to insure uniform growth of an animal and get the full feeding value of all the constituents of a forage, the ration must be properly balanced. The nutritive ratio of cowpea hay is narrower than can be properly utilized by the animal, and to get the full benefit of all the crude protein in the plant, hay or coarse fodder containing an excess of the carbohydrates must be added to the daily ration. A practical farmer, writing from southern Mississippi, says that excellent results were obtained through feeding two parts of cowpea hay to one part of crab grass or timothy, and when using this ration very little grain was required, especially when the hay contained much of the pods. If cowpea hay be fed without the admixture of some coarse forage or grass hay, a portion of the protein will be wasted through inability of the animal to digest and assimilate the whole amount. Cowpea hay is used on many of the Southern sugar and rice plantations for the horses and mules, and it is found that work stock keep in excellent condition upon it, requiring very little grain.

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[*] The numerical relation which the protein of a feed bears to the carbohydrates (and fat reduced to carbohydrates) is termed its nutritive ratio. Fat is multiplied by 2¼ to convert it into carbohydrates. If a ton of feed should contain 96 pounds of digestible protein and 928 pounds of digestible carbohydrates, it would have 9.6 times as much carbohydrates as protein, or 1:9.6, which is its nutritive ratio.—J. B. LINDSEY.

FERTILIZERS.

It has been found that, as a rule, it does not pay to use high-grade commercial fertilizers on cowpeas; this, however, depends a good deal on the soil and on what crop is to follow. It is usually unprofitable to fertilize with expensive nitrogen, in the form either of nitrate of soda or of guano, and even the organic nitrogen of cotton-seed meal does not act upon this crop as rapidly as upon cotton and the cereals. The nitrogen of the fertilizers seems not to influence the percentage of protein in the crop, and the general opinion of agriculturists in the South is that it does not cause a sufficient increase in yield of vines to pay the cost. At the Delaware Station 160 pounds of muriate of potash per acre doubled the yield of vines, and superphosphate produced no effect. At the Georgia Station combinations of superphosphate and potash gave the best results, but later experiments there indicated that large amounts of potash are unprofitable, and that superphosphate at the rate of from 200 to 400 pounds per acre gave better results. Superphosphates are very much preferable to untreated rock phosphate. The latter can be sold at lower rates, and it remains to be seen whether it would not be a profitable method to apply the soft phosphate to the cowpeas for the benefit of the succeeding crop in the rotation, for it has been found that the insoluble phosphoric acid of the untreated rock becomes changed to forms available as plant food in the presence of large amounts of decaying vegetable matter in the soil. If it is found that this process can be relied upon, then the cowpea will have another valuable quality added to it, namely, that of being able to change into high-grade and more costly superphosphate the low-grade and cheap but unavailable phosphoric acid of the untreated rock.

The chief functions of this crop, then, are to furnish large amounts of nitrogen abstracted from the air and fixed in the roots and stubble in a conveniently available form for the use of succeeding crops; second, to produce a large yield of vines and peas rich in digestible protein, which, either as hay or for soiling purposes, will take the place of concentrated nitrogenous foods; and, third, to supply humus, which acts directly and indirectly to produce fertility by breaking down and rendering available the basic minerals of the soil. The fertilizing value of the nitrogen in the vines is entirely dissipated or greatly diminished by weathering when they are left on the surface of the field during the winter. Hence, to secure the full value, the cowpeas should be fed and the stable manure returned to the field. If the vines are plowed under in autumn, a winter forage crop, such as winter oats, crimson clover, rye, or vetches, should be planted to prevent the leaching and washing action of the winter rains.

FARMERS' BULLETINS.

The following is a list of the Farmers' Bulletins available for distribution, showing the number, title, and size in pages of each. Copies will be sent to any address on application to Senators, Representatives, and Delegates in Congress, or to the Secretary of Agriculture, Washington, D. C.:

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86. Thirty Poisonous Plants. Pp. 32.
87. Experiment Station Work—VIII. Pp. 32.
88. Alkali Lands. Pp. 23.
89. Cowpeas. Pp. 16.
90. The Manufacture of Sorghum Sirup. Pp. 32.
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U. S. DEPARTMENT OF AGRICULTURE.

FARMERS' BULLETIN No. 90.

THE

MANUFACTURE OF SORGHUM SIRUP.

BY

A. A. DENTON,
Medicine Lodge, Kans.

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1899.

LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
DIVISION OF CHEMISTRY,
Washington, D. C., January 3, 1899.

SIR: I have the honor to transmit herewith the manuscript prepared by Mr. A. A. Denton, of Medicine Lodge, Kans., on the manufacture of sorghum sirup.

In submitting the manuscript the author says:

> In the following pages the simplest means only, suited to sirup makers who have limited facilities, are considered.
>
> A considerable improvement in the quality of sorghum sirup is effected by removing all suspended impurities from the juice. The impurities which neither rise nor settle, and which are not successfully filtered out, injure the product. In this article the matter is considered, being the first and simplest step in the effort to improve the quality of sorghum sirup. The consideration of the second step, the removal of soluble impurities, is reserved for a second article. The removal of these matters is essential to the production of a finished first-class table sirup, and it is intended to work experimentally in that line the coming season, and to test and to develop the most practicable process for removing both the solid and suspended impurities, and also the soluble impurities from sorghum juice, so as to prepare a high-grade table sirup, in place of the crude product which has heretofore been made.

Mr. Denton has devoted many years to the study of the problems connected with the culture of sorghum cane and the manufacture of sirup. Owing to his large practical experience in this work, this article should be of value to the many thousand farmers who annually produce sorghum sirup for their own use and for local and other markets. I therefore recommend that it be published as a Farmers' Bulletin.

Respectfully,

H. W. WILEY,
Chief of Division.

Hon. JAMES WILSON,
Secretary of Agriculture.

CONTENTS.

Page.

Definitions 5
  Sorghum 5
  Molasses 6
    Centrifugal molasses 6
Sorghum sirup and sugar-cane sirup compared 7
    Little change in processes of making sirup 8
Statistics of sorghum production 9
Sorghum in semiarid sections 9
Improved varieties of sorghum 10
Experiments by the Department of Agriculture 11
Experiments by the Kansas State Experiment Station 11
  Varieties of sorghum selected for sugar manufacture 12
  Need of systematic selection of varieties of sorghum suitable for sirup manufacture 13
Preparing the soil, planting, and cultivation 15
Grinding cane 17
    Horsepower mills 17
Clarifying the juice 18
    The use of lime 19
Skimming, settling, and filtering 21
Claying the juice 22
Settling tanks 25
Evaporating 26
Superheating sorghum juice 27
Summary 27
Letters from representative sirup makers 29

ILLUSTRATIONS.

Page.
FIG. 1. Seed heads of the Collier variety of sorghum........................ 12
2. Seed head of the Amber orange sorghum........................... 13
3. Seed heads of the Colman variety of sorghum........................ 14
4. Seed heads of Folger's Early variety of sorghum..................... 15
5. Jar and spindle used for determining the density of sorghum juice and sirup 22
6. Settling tanks for cold clarification.................................... 23
7. Glass tube and bottle used to show how far the juice has settled...... 24
8. Settling tanks for hot clarification..................................... 25
9. Tanks for cold and hot settling... 28

THE MANUFACTURE OF SORGHUM SIRUP.

DEFINITIONS.

The word "sorghum" has a double meaning. It is the name of a cane-producing race of plants, and it is also often used as the name of the sirup which is produced from sorghum canes. To avoid confusion, the words "sorghum plant" and "sorghum sirup" are sometimes used instead of "sorghum." The words "sorghum plant" have also a double meaning. Machinists use the word "plant" as a collective name for the apparatus and machinery required to do certain work. A "steel plant," for instance, is the name for all of the machinery required to produce steel, and a "sorghum plant" would be understood by some to be the apparatus required in manufacturing sorghum, and by others would be understood to refer to the sorghum race of plants.

SORGHUM.

The word "sorghum" is generally understood to include only the sweet, saccharine, sugar-producing varieties of canes. Botanists include in the term, Kafir corn, Jerusalem corn, rice corn, broomcorn, durra, milo maize, and many other so-called nonsaccharine varieties of sorghum. These hybridize, or cross, or mix with each other, and also with the saccharine varieties. They are closely related and belong to the same family of plants. All of the "nonsaccharine" varieties produce more or less sugar, having a content of 2 per cent and more in the juice, merging into the "saccharine" varieties, which contain from 10 to 15 per cent of sugar in the juice. These two classes of sorghum have no distinct line of separation. A variety of sorghum may be said to be nonsaccharine when its juice contains too little sugar for the practical manufacture of sugar or sirup.

When the juice of sorghum canes is clarified in the usual ways, and is concentrated by evaporation until a gallon weighs, approximately, 11½ pounds, the product is known as sorghum sirup or molasses, or as "sorghum." Sugar-cane sirup made in the same way is known in Louisiana as "sirup," the descriptive words "sugar cane" being well understood. It is usually made less heavy than sorghum sirup, and is of less weight than is generally desired by sirup consumers. When reduced to a density of 11½ pounds per gallon, a part of the sugar contained in the sirup is likely to crystallize, and the thin molasses remaining after the partial crystallization of the sugar is liable to ferment. Sugar-cane sirup and sorghum sirup are the concentrated juices of the canes, the easily separated impurities of the juice being removed by more or less imperfect processes of clarification, no sugar being taken from the sirup.

MOLASSES.

Molasses is what remains when more or less of the sugar contained in the sirup has been extracted. In many parts of the country, however, sorghum sirup is called molasses. In Louisiana molasses is classed in two kinds—"O. K.," that is, open-kettle or open-pan molasses, and "centrifugal" molasses. Open-kettle molasses is made in the same way as sugar-cane sirup, but the sirup is boiled in open pan to greater density than is usual in sugar-cane sirup. A part of the sugar in the sirup crystallizes and is removed. The remaining molasses is then reboiled until it is sufficiently thick and heavy. As the excess of sugar has been extracted, the remaining molasses can be concentrated to greater density than is usual in sugar-cane sirup, and the final product is less liable to crystallize or to ferment. As it still contains considerable sugar, this open-kettle molasses is in active demand for use as human food. It is often sold at as high a price or at a higher price than sugar-cane sirup from which no sugar has been taken. In the market reports, sugar-cane sirup and open-kettle molasses are not infrequently quoted before the close of the season with the addition of the words "None in first hands." It is said that the manufacture of sugar-cane sirup and of open-kettle molasses is in many cases as profitable as the manufacture of sugar, and requires less capital and skill; also that the quality of sugar-cane sirup and of open-kettle molasses made in small and cheaply equipped factories is fully equal, and often superior, to that made in costly factories which work on a much larger scale.

CENTRIFUGAL MOLASSES.

Centrifugal molasses is the poorest marketable product of sugar cane. It is what remains when as much sugar as possible has been extracted from the sirup. It is the residue of sugar manufacture. It contains but little sugar, and all of the impurities left in the juice by imperfect clarification. Centrifugal molasses has deteriorated in quality in recent years because of the improved method of extracting the sugar. So much sugar is extracted that the remaining molasses is often so impoverished that it has little value. It is sometimes sold at very low prices, is fed to stock, fermented, or thrown away. It has been proposed to burn it or to return it to the soil. Sugar cane is grown in seven States. In those sections in which but little sugar is made the molasses has a high average value. The yield of molasses and its value are lowest in the great sugar-producing sections. The reason is that in the former sections the molasses is the principal object of cane manufacture, while in the latter sections the molasses is sacrificed in order to obtain the greatest possible yield of sugar.

In sugar-cane sirup there is often an undesirable excess of sugar. In open-kettle molasses the excess of sugar has been removed. In centrifugal molasses as much sugar has been extracted as is possible.

In each one of these classes there is a wide range in quality and in value. There are as many as ten commercial grades, namely, "Fancy," "Choice," "Strict prime," "Good prime," "Prime," "Good fair," "Fair," "Good common," "Common," and "Inferior." At this writing sugar-cane sirup, in its home wholesale market, New Orleans, brings 26 to 28 cents a gallon; open-kettle molasses, 21 to 32 cents, and the medium grade, "Good fair," 25 cents a gallon. Centrifugal molasses now brings from 8 to 20 cents, and the medium grade, "Good fair," 12 to 13 cents a gallon. In Northern wholesale markets sorghum sirup of average quality brings less than sugar-cane sirup, less than open-kettle sugar cane molasses, and ranks in the great trade centers about the same as the middle grades of centrifugal molasses.

SORGHUM SIRUP AND SUGAR-CANE SIRUP COMPARED.

The manufacture of sugar-cane sirup and molasses is worthy of careful study by sorghum-sirup makers. It is said that in the manufacture of sugar from sugar cane or sugar beets from one-half to three-quarters of the expense is in procuring the cane or the beets. Sorghum cane is produced more cheaply than either, having 13 or 14 pounds of sugar in 100 pounds of the juice. When such cane is properly utilized it should be worth $2 a ton to the cane grower and $4 a ton to the manufacturer, giving a profit to both. It is possible to clarify sorghum juice of average quality so as to remove the impurities which give the sirup its undesirable qualities, and to secure a product which is as acceptable as sugar-cane sirup or molasses.

When the impurities in sorghum juice, which give the sirup its undesirable qualities and which also hinder crystallization, are removed, the sirup is improved in quality, and also crystallizes readily. When first-class sirup is made from sorghum it is necessary to extract the excess of sugar from it and make open-kettle molasses, as is done with sugar-cane sirup. This is necessary to make the excess of sugar in the sirup uncrystallizable, as is sometimes done in the manufacture of sugar-refinery sirups. In an attempt to improve the quality of sorghum sirup by using superior means for clarifying the juice, the writer made 6,000 gallons of sirup, which had 6 pounds of sugar in each gallon and which yielded 4 pounds of unrefined sugar of good quality from each gallon. But such sirup when reduced to the density required for sorghum sirup becomes "mush sugar," which is a mixture of sugar and molasses. It can not be relied on to remain sirup. In this case, after the excess of sugar had been extracted, the remaining molasses was reboiled to thick molasses, which was open-kettle sorghum molasses. It was sold at the same price that the sirup was worth before the extraction of the sugar.

LITTLE CHANGE IN PROCESSES OF MAKING SIRUP.

The manufacture of sugar-cane sirup and of sorghum sirup has changed little in the past forty years. The processes now used are essentially the same as they were then. A little lime, heat, a partial separation of impurities from the juice by skimming or settling, or both, and evaporation by open pan are the means generally employed. This lack of progress is in striking contrast with the improvements which have been made in nearly all other manufacturing processes during the past forty years. Improvement in sugar-cane sirup manufacture is much less necessary than it is in the manufacture of sorghum sirup, because sugar-cane juice is naturally much purer than sorghum juice. When 100 pounds of Louisiana sugar-cane juice are evaporated to dryness, about 90 per cent of the dry solids which were in solution in the juice consist of cane sugar and glucose and about 10 per cent of the dry residues consist of substances which are neither cane sugar nor glucose. In the dry residues of sorghum juice, about 75 to 77 per cent consist of cane sugar and glucose, and nearly one-fourth of the solids which were in solution consists of substances which are neither cane sugar nor glucose. Sorghum juice contains fully twice as much impurity as sugar-cane juice. It is this excess of vegetable impurities which places sorghum-sirup manufacture at a disadvantage. When the excess of impurity is removed, the disparity between sugar-cane sirup and sorghum sirup ceases. Sorghum-sirup manufacture has declined, and must continue to decline, unless purer juice can be obtained from better varieties of sorghum, or unless the juice can be made purer by better clarification.

The fact that the quality of sorghum sirup or of sugar-cane sirup has not improved in the past forty years is not good cause for abandoning attempts to improve the manufacture of either. It was sixty-five years after Margraff began the manufacture of beet sugar that Barruel discovered the carbonatation process of purifying beet juice which is now successfully used in making 5,000,000 tons of beet sugar annually. It was sixty-four years after the Russian chemist Kirchoff began glucose manufacture that American glucose manufacturers found the right way out of their difficulties, enabling them to produce at the present time 1,000 tons a day of liquid corn sirup and solid starch sugar. It is now only necessary to find the way to purify sorghum juice properly in order to quickly develop an extensive and profitable manufacture of sorghum sirup. It is not necessary that a great invention or discovery should be made. Some of the methods of clarifying saccharine liquids which have been developed and successfully used by beet-sugar makers, cane sugar makers, sugar refiners, or by glucose makers may be found to be also adapted to the clarification of sorghum juice. These pages are written with the purpose of stating the facts and the difficulties of sorghum-sirup manufacture in a general way, with a hope of inducing sirup makers to improve their processes rather than with the intention of assuming to state the precise methods to be used.

STATISTICS OF SORGHUM PRODUCTION.

The improvement of sorghum-sirup manufacture is not a small matter, nor is it a matter of merely local importance. The production of sorghum sirup was, in 1860, 6,749,123 gallons; in 1870, 16,050,089 gallons; in 1880, 28,444,202 gallons; and in 1890, 24,235,218 gallons.

In 1889, 11 States produced over a million gallons of sorghum sirup each. It was produced in greater or less quantities in 44 States and Territories. Missouri, Tennessee, Kentucky, Arkansas, Texas, Kansas, Iowa, Georgia, North Carolina, Alabama, and Illinois, in the order given, produced the largest quantities, ranging from 2,721,240 gallons in Missouri to 1,110,183 gallons in Illinois. The report of the Kansas State Board of Agriculture shows that in 1890 that State produced 3,431,100 gallons of sorghum sirup, not 1,484,937 gallons, as stated in the national census returns, thus placing Kansas easily first instead of fifth in sorghum-sirup production.

These statistics show the adaptation of sorghum to a wide range of conditions of soil and climate, scarcely second to that of corn. Sorghum succeeds in semiarid sections where corn often fails. Its cultivation extends far to the north, 3,890 acres being grown in Minnesota, and to the south, 1,755 acres being grown in Louisiana for sirup production. Its acreage is greatest in the States of the plains, Kansas having in 1898 nearly a million acres of all varieties, saccharine and nonsaccharine.

The census of 1890 shows that sorghum-sirup production had declined as compared with the census of 1880 in thirteen States and had increased in eight States. Generally the production had declined in 1890 about 15 per cent from that in 1880. It is believed it has declined still further since 1890. The conditions of sorghum-sirup manufacture in 1899 disappoint the hopes that were cherished in the years 1850 to 1880. In order to bring prosperity to this declining industry, it is necessary to improve the method of manufacture so as to produce a first-class finished table sirup, which will be in demand by all classes of people, instead of the crude, acid, turbid, rank-flavored, and dark-colored sorghum which is often made by the primitive processes now used.

SORGHUM IN SEMIARID SECTIONS.

In recent years the acreage of sorghum has immensely increased in the semiarid sections of the West. The ability of sorghum to endure drought is a very valuable quality of the plant, for it enables it to live where other plants often perish. Sorghum was brought to this country from the arid sections of Asia and Africa, and it has the ability which is found in plants in arid sections to suspend growth when moisture is lacking and to renew growth when rains come. But the sorghum-sirup manufacturer in semiarid sections has more need for efficient means for removing impurities from the juice than those in more uniform climates. The canes are at times wilted and drooping, the juice containing from one-fifth to one-fourth of its weight of solid matter. Impurities often do not settle well from such dense juice. When rains come the canes renew their growth. The juice is then loaded with vegetative matter, which often neither rises well as scum nor settles well as sediment. Intermittent growth of the canes caused by drought and flood often impairs the quality of the sirup which is produced in the semiarid sections. As a rule, the sirup produced in such localities is inferior in quality to that produced in more regular climates, where the canes are subjected to fewer droughts and floods. All sorghum-sirup makers need more efficient means for purifying the juice. The sirup makers in the semiarid sections, in which the largest acreage is grown, have especial need for better separation of the excessive amount of vegetative impurities which their sorghum juice often contains.

There seem to be two ways in which the quality of sorghum sirup may be improved. The first is the selection of varieties of sorghum which yield purer juice, or which yield impurities which are less objectionable or which may be more easily removed from the juice. The second way is the use of more efficient processes for purifying the juice or the sirup.

IMPROVED VARIETIES OF SORGHUM.

There are many hundreds of varieties of sorghum. They differ in external qualities, such as size, height, yield of seed, color of seed top, time of maturing, etc. They also differ in quality of juice, such as the amount of sugar contained and the percentage of glucose, and they probably also differ in the nature, kind, or quantity of impurities contained in the juice. In the numerous varieties of sorghum which are known there are surely a few which are preeminently adapted to sirup manufacture. There are many varieties of the maple tree—one, the rock maple, is esteemed as the best for maple-sirup manufacture. There are many varieties of the palm tree—one, the sugar palm, is considered the best for sirup or sugar manufacture. The "Creole" cane in Louisiana is considered the best for some uses, and some other varieties the best for sugar manufacture. It seems evident that all varieties of sorghum are not exactly alike in any respect, and that a few are certainly superior for sirup manufacture. There are many kinds of sorghum which have never been tested properly, in a strictly comparative way, in sirup manufacture. Gardeners, grain and fruit growers, and florists know that the planting of certain varieties is essential to success and there is a general agreement among them in regard to the best ones. There is no such general agreement among sorghum-sirup makers in regard to the best kinds for their purposes, except that early-maturing canes, the Early Amber for instance, are best in sections where the growing seasons are short. The writer obtained 200 samples of sorghum sirup from twenty States, with statements in regard to the varieties preferred, soils, and methods of manufacture used. No satisfactory conclusions could be formed from these samples or statements.

When varieties have been chosen for sugar or for sirup manufacture, for grain or seed production, for forage or for broom making, they may be much improved by the selection of seed from the best plants. Sorghum responds quickly to efforts made to improve it by the selection of seed. It was imported from countries in which selections for quality of juice had not been made. In an undeveloped plant or race of animals the first improvement caused by selection is often rapid, and the last improvement is slow, as it nears the limit of improvement. When a plant is transferred to another country, as was the case with sorghum, it often varies to meet the new conditions, and thus new, often superior, varieties are produced. This is true of the apple, the grape, the chrysanthemum, and many other plants. The best of these for this country are American varieties which sprung from those which were imported. These are sometimes superior on American soil to those from which they sprung on their native soil. The same will doubtless be true of sorghum when selections have been made, as has been done with other plants.

EXPERIMENTS BY THE DEPARTMENT OF AGRICULTURE.

In the years 1888–1893 the Department of Agriculture experimented in the improvement of sorghum cane for sugar manufacture by the selection of varieties and seed from single canes of superior quality. In reviewing the results Dr. H. W. Wiley, Chemist of the Department, said: "The data indicate most clearly a gradual, in some cases a rapid, improvement in a larger quantity of sucrose, a smaller quantity of glucose, and in a higher purity."

EXPERIMENTS BY THE KANSAS STATE EXPERIMENT STATION.

The Kansas State Experiment Station also attempted the improvement of sorghum cane for sugar manufacture by the selection of seed. The results are stated as follows:

> The work in seed selection has been in progress five years and has been attended with a constant improvement in the quality of sorghum. Indeed, it seems that the plant may be modified in almost any desired direction.

VARIETIES OF SORGHUM SELECTED FOR SUGAR MANUFACTURE.

In five years of experimenting in improving varieties of sorghum for sugar manufacture five were selected which contained much more sugar in the juice than the common canes. Sorghum has been and may be improved for sugar manufacture. It may also be improved for sirup manufacture. The varieties selected for sugar manufacture were:

The *Collier*, imported from South Africa. It is the best or one of the best varieties for sugar manufacture, having a very high percentage of sugar and a low percentage of glucose or uncrystallizable sugar in the juice. It does not yield seed abundantly, nor are the canes large, averaging about a pound in weight. Though slender,

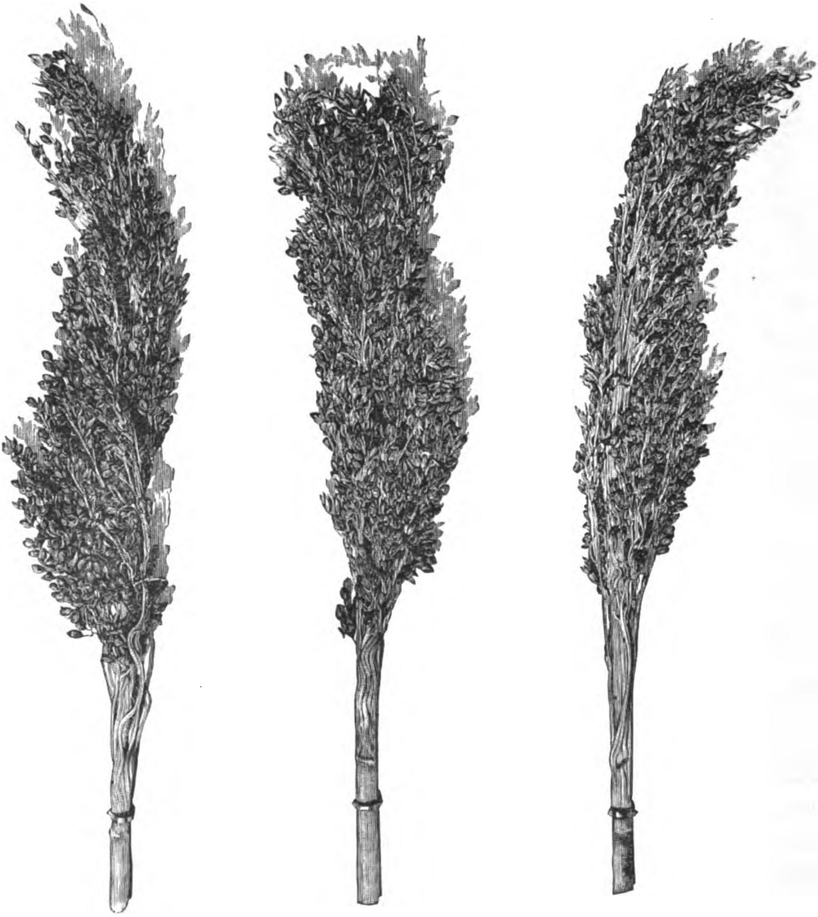

FIG. 1.—Seed heads of the Collier variety of sorghum.

canes of this variety are believed to be tangled, broken, or prostrated by wind storms less often than other canes. There are some who believe it to be one of the best varieties for forage.

The *Amber-Orange* originated in a cross between Early Amber and Kansas Orange. This cane was tested for five years by the Kansas State Experiment Station, and was considered one of the best for sugar manufacture. It does not produce seed abundantly.

The *Colman*, also a cross between Early Amber and Kansas Orange, is generally preferred because it produces canes of good size, not tall, with juice of good quality, and also produces seed abundantly.

Variety 161 originated in a cross between Early Amber and Link's Hybrid. The canes are tall and slender, which is a fault derived from Link's Hybrid. It ripens rather early, much earlier than Link's Hybrid. Its juice remains good, ordinarily, long after the canes are ripe, though standing uncut in the field. The juice has, on an average, as large content of sugar as the average juice of Louisiana sugar cane, and much less glucose or uncrystallizable sugar.

Folger's Early is also a cross between Early Amber and Link's Hybrid. It ripens not long after Early Amber and remains good, standing uncut in the field, much longer than Early Amber. It yields more cane and more seed per acre than Early Amber. It is considered the best early-maturing variety for general planting.

The *Early Amber* variety, a quick-maturing cane, is liked better in the North than in the South. It is the best variety for early ripe cane or for late planting, and for sections in which the growing season is very short.

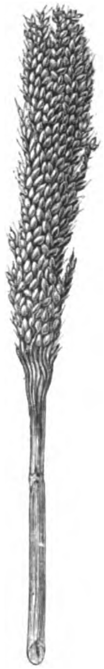

FIG. 2.—Seed head of Amber-Orange sorghum.

NEED OF SYSTEMATIC SELECTION OF VARIETIES OF SORGHUM SUITABLE FOR SIRUP MANUFACTURE.

It is believed that in five years of similar tests of all obtainable varieties of sorghum, and of many crosses and variations, five varieties could be selected and developed which would be as much superior for sirup manufacture as are the above-named for sugar manufacture.

Those who grow cane mainly for the seed or grain have very generally selected Kafir corn, a nonsaccharine variety of sorghum, as being the best for their purpose. The Dwarf and the Standard varieties of broom corn, also nonsaccharine varieties of sorghum, have been selected by manufacturers of brooms, as being decidedly superior to all others for their purpose. Those who grow sorghum for forage, for "stover," or "roughness," and also those who grow sorghum for sirup manufacture have not yet learned which kinds of sorghum are superior for their purposes. Selections for sirup manufacture should be made by testing on a small scale, in a strictly comparative way in the laboratory, all obtainable varieties, and by again testing in a practical way those which seem best. Such experimental work would doubtless benefit those who produce the twenty million or more gallons of sorghum sirup now produced annually in this country, and would also benefit those who consume the sirup.

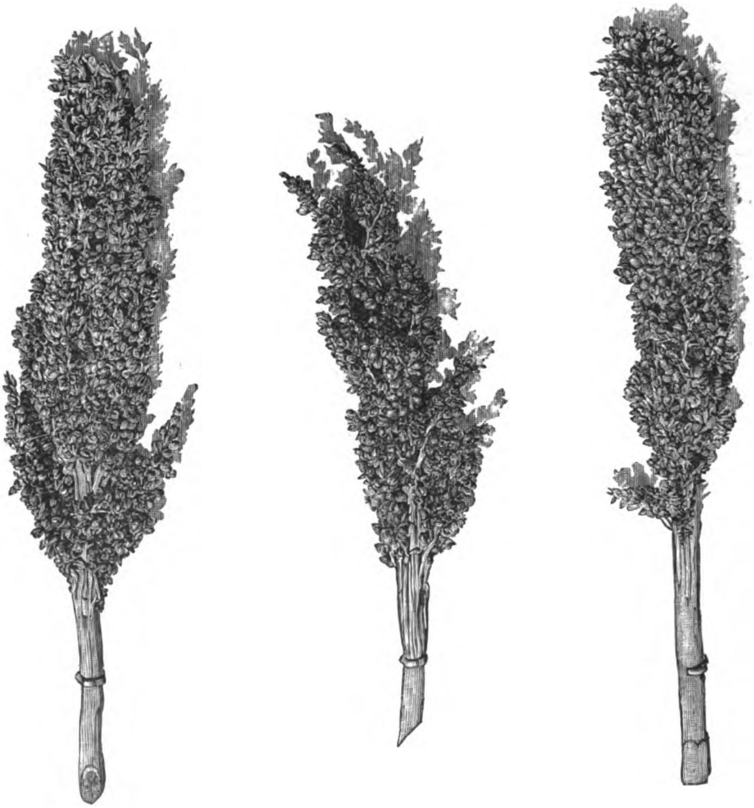

FIG. 3.—Seed heads of the Colman variety of sorghum.

At the present time, it is impossible to say which varieties of sorghum are best for planting for sirup manufacture. Those which have been selected as best for sugar manufacture are not, perhaps, best for producing sirup. The McLean variety, for instance, is, by chemical analysis of the juice, one of the best for sugar manufacture, but its juice has often if not always an unpleasant flavor, and the sirup is of poor quality. Varieties which are best for sugar making are quite likely to give sirup which crystallizes or grains readily. This is desired by sugar makers but not by sirup makers.

PREPARING THE SOIL, PLANTING, AND CULTIVATION.

Sorghum is so extensively grown over a wide area, and in such different conditions of soil and climate, that quite a variety of methods of growing the canes are employed. In the semiarid sections of the West, where most of the sorghum is grown, the greater part is "listed." A double-moldboard plow with a planting attachment is used to make furrows the proper distance apart for the cane rows, throwing up ridges between the furrows and planting the seed at or near the bottom of the furrows, considerably below the level of the field. In some sections of the South cane is planted upon ridges, above the level of the field, in order to secure drainage. In other sections the land is plowed, harrowed, and the seeds planted at the level of the surface. Those who "list" believe that method is, for them, the cheapest way to prepare

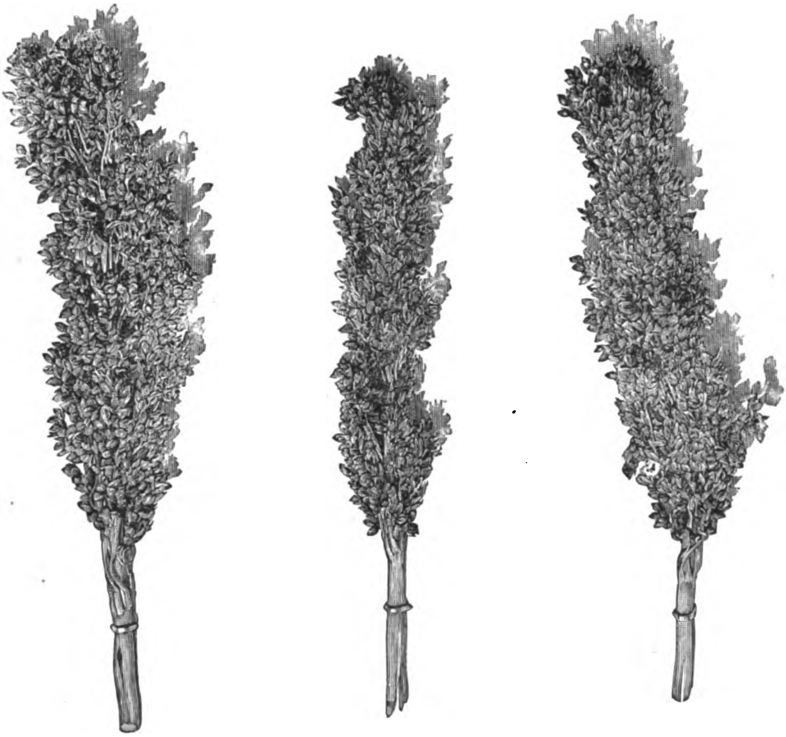

FIG. 4.—Seed heads of Folger's Early variety of sorghum.

the soil and plant the seed; and that it is easier to cultivate the crop, the soil being worked down to the canes by the cultivations, so that when the crop is "laid by" the canes are on the level or are but slightly hilled. They also believe that this method utilizes scanty rainfall better, the water flowing to the canes instead of away from them, as happens when the canes are hilled. It is more difficult to keep the rows of cane free from weeds when planted above the level of the soil. Planting the seeds at the level of the field is safer than listing, because sorghum is small and grows very slowly in its first weeks, and when the seeds are placed below the level the plants are liable to be covered by sand or dust storms, or by flooding rains. Sorghum should be planted and cultivated as is best for corn in any given locality. More care is needed in the first cultivation to work close to the rows and to avoid injuring the "stand" by covering the plants, than is considered necessary for corn.

The rows of cane are usually 3 feet 6 inches or 3 feet 8 inches apart, and, in order to give room for full development of the canes, the plants should be not less, generally, than 4 inches apart. There are few who "check row" sorghum and cultivate in two directions crosswise. There are some who prefer to have the rows 4 feet apart and to have the canes 6 inches apart in the rows. In the West, thinning the plants to a proper stand is seldom done. Usually, thinning is insufficiently done and the canes are too close together for the best development. Such canes suffer more from drought than when rightly planted. It is believed that nothing is gained by very early planting, and that it is better not to plant until the soil is warm and the weeds have started. In the West, two or three cultivations are usually given. Cane seed is often imperfectly cleaned for planting. No planting machine is known which plants trashy sorghum seed correctly and regularly. The fibrous stems and imperfectly thrashed seeds remain in the seed box and hinder proper dropping of the seeds. It is better to "pan" the seeds when planting, as gold diggers in placer mining "pan" earth and sand. By giving the pan a shaking or whirling motion the clean cane seed settles to the bottom and the trash is then readily removed by hand from the surface. When sorghum seed is of mixed varieties which ripen at different times, the canes produced are often unripe, ripe, and overripe in the same row. After the canes have been harvested, examination of the stubble often shows that if there had been fewer vacant spaces in the rows, fewer places where the canes were too far apart or too close together—that is, if more care had been taken in the planting and in the cultivation—a much larger yield of cane of better quality for sirup manufacture could have been had with no additional expense. When the cultivation is done at the right times it is often much more effective and more easily done than when done at other times. It is not as easy to plant sorghum so as to get a good stand or to do the first cultivation well, cleaning the rows, without injuring the stand, as in growing corn.

GRINDING CANE.

Tropical sugar cane is usually harder to grind than Louisiana sugar cane. The latter, though much larger and harder than sorghum cane, gives better extraction of juice. A ton of average sorghum cane may be made to yield 20 gallons of sirup. It usually yields from 10 to 12 gallons. Where cane is cheap and abundant it is often considered inadvisable to greatly increase the extraction of juice by excessive pressure of the canes. Juice obtained by moderate pressing is purer than that obtained by extreme pressure, for this extracts not only more juice, but also more impurity from the shell and the joints of the canes. With limited power, a larger quantity of sirup can be made in a given time from moderately pressed cane than from a less quantity of cane subjected to greater pressure. But there is generally much unnecessary waste of juice in grinding sorghum cane. The rolls often need to be "turned"—that is, reduced to even diameter, the bearings need babbiting, and the rolls need to be properly adjusted to each other. The "feed"— that is, the amount of cane in the mill at one time—should be light or heavy according to the adjustment of the rolls. When the rolls are set "open" the feed should be heavy; when they are set close together the feed should be thin, or light; but in both cases the feed should be regular and uniform. It is evident that when the rolls are set "open", or apart, there is waste of juice when the feed is light, and also that canes can be well pressed though the rolls are not set close provided the feed is heavy.

HORSEPOWER MILLS.

When a horsepower cane mill is set up higher above the ground than is necessary, a part of the power of the horse is uselessly expended in twisting the "sweep" or lever. If it be set too low, it is inconvenient for work. The cap—that is, the casting to which the sweep is attached—should be about 60 inches above the ground. The hitching point of the sweep should not be much above or below that used when attaching a horse to farm implements. A double sweep—that is, two levers opposite each other, having an evener or equalizer of rope, wire, or chain, passing over the double sweep—is better than a single sweep, having two horses working together. It is better to have the circle or path traveled by the horse of not less diameter than 25 feet. A horizontal lever or sweep, such as is used in miners' hoists or "whims," seems much better than a curved sweep, the lever being less in the way of the work. The horse works under the sweep and is attached high up, only a few links of chain being used for traces, hence there is less loss of power. But such attachment is more expensive in first cost. A stiff sweep is said to do better work than one that is flexible. A first-class mill, well adjusted and properly fed with cane, is usually cheaper and more effective in the long run than a cheap mill which is carelessly operated.

It is said that, for horsepower, vertical mills which permit the sweep to be directly attached to the shaft of the main roller, cost less, require less power, last longer, and get as good extraction of juice as mills having horizontal rolls. A four-horse mill is as large as is profitable for horsepower. Larger mills should be operated by steam or water power. The separate horsepower cane mill seems to require a large excess of power. Two horses, or even one horse, can be used on a four-horse mill when desired. It is convenient to use a four-horse mill, grinding cane and settling the juice in the forenoon, evaporating the settled juice to sirup in the afternoon—not grinding cane then—giving ample time for well settling the juice, and making night work unnecessary. As much sirup can be produced in this way with the same help as can be produced with a small mill which grinds cane all day, finishes often in the night, and gives too little time for proper clarification of the juice.

CLARIFYING THE JUICE.

In modern manufactures there is a marked tendency to the use of complex processes instead of the few and the simple processes which were formerly used. The manufacture of flour, for instance, was for thousands of years a very simple matter. Now a flouring mill is a factory filled with machines, each performing a part and having a purpose unthought of in old times. In the manufacture of sugar-refinery sirups, and of glucose, and in purifying beet juice for sugar manufacture, as many as ten clarifying processes are often used. In the manufacture of sugar from sugar cane, although that is a comparatively simple matter, the juice is purified in more ways than it is in the manufacture of sirup. Sugar-cane juice is filtered once, sometimes twice; beet juice is generally filtered twice, sometimes three or even four times. Sugar makers and refiners use all known effective processes in clarifying their liquids, yet they have not so impure a liquid to deal with as sorghum-sirup makers. Their products are superior and their manufacture is successful, because they employ many processes instead of the simple processes which are used in sorghum-sirup manufacture. The question is often asked, What can I put into sorghum juice so as to make good sirup? No single process is known which will remove all undesirable substances from sorghum juice at one operation. It is said that as many as fifty substances have been identified in beet juice. Probably sorghum juice is as complex. It contains a larger percentage of vegetable impurities than beet juice.

It contains several classes or kinds of impurities. Clarification of the juice is a process of subtraction, removing the various classes of impurities by different methods. The use of lime, neutralizing natural acids contained in the juice, helps to remove some of the impurities, while heat coagulates others. Some of them are lighter than the juice and rise to the surface, and may be removed by skimming. Other impurities are heavier than the juice and settle, and may be removed by drawing off or decanting the clarified juice, leaving the sediment. Some neither rise nor settle, and can be removed only by adding albuminous substances, such as milk, blood, white of egg, etc. These coagulate in the liquid and rise to the surface, bringing up the impurities which were suspended in the juice, and which may then be removed by skimming. Suspended impurities may also be removed by weighting them with clay, or other suitable substances, which causes them to settle, after which the clarified juice can be removed by decantation. The suspended impurities may also be removed by filtering, the filtering material allowing the juice to pass through, but restraining the solid matters contained in it. When all of the solid impurities contained in sorghum juice are removed by skimming, by settling, or by filtering, there remains a class of impurities in solution, and which can not be removed by mechanical means only. When those which are in solid form and those which are in solution are well removed, the sirup which is produced is fully equal to any cane sirup in the market. Improvement in the quality of sorghum sirup is to be looked for in the use of efficient processes for removing the solid impurities, and, also, the impurities in solution in the juice, thus producing a finished first-class table sirup.

THE USE OF LIME.

Nothing has been found better than lime for neutralizing the acids contained in sorghum juice. It is used by all cane-sugar and beet-sugar makers and sugar refiners as a necessary means for clarifying their liquids. The use of lime in sorghum juice is, in some respects, quite unsatisfactory. The juice is always acid, sometimes strongly acid. Sirups containing all of the acids naturally in sorghum juice, concentrated by evaporation, from 6 to 8 gallons of juice to 1 gallon of sirup, are too acid to suit the great majority of sirup users, who are accustomed to the mild, neutral sirups made by refiners and mixers. The acids also hold impurities of the juice in solution, so that these can not be removed. Proof of this is seen when sorghum juice is limed until neutral—that is, neither acid nor alkaline. A part of the impurities then becomes solid. By adding acid to the juice these solid impurities redissolve and go into solution in the juice again. But lime not only neutralizes the acids; it also attacks and degrades other substances in the juice. A large quantity of lime is used in beet juice without harm. A larger quantity can be used in sugar-cane juice with less harm than can be used in sorghum juice. When a sample of sorghum juice is limed to excess on a cool morning it is seen that the juice is not discolored when the temperature is below 59° F. It becomes slowly discolored when the temperature rises above 60°. It is rapidly discolored above 80°, and is instantly discolored at the boiling point. This seems to indicate that it is better to lime the juice when cold. Lime changes by keeping, losing strength by absorbing carbonic-acid gas from the air and forming more or less carbonate of lime. Lime is but slightly soluble in water. Seven hundred pounds of water dissolve 1 pound of lime, and it does not long remain in suspension in water, so that the phrases "milk of lime" or "cream of lime" convey an indefinite idea of the amount of lime contained in the liquid. Common lime is also often made from very impure limestone. As has already been said, sorghum juice varies greatly in degree of acidity, sometimes requiring much more lime than at other times. For these reasons it is not possible to form a general rule for liming sorghum juice, except that after the process the juice should always slightly redden a strip of blue litmus paper which has been immersed in the limed juice. This indicates that the juice is still slightly acid and that too much lime has not been used. It is unsatisfactory to use too little lime, difficult to use the proper quantity, and the sirup is injured when too much is used. When too little lime is used, the clarification is imperfect, the juice is gummy and can not be filtered, and the sirup has a more or less rank flavor. When lime is rightly used, a larger amount of impurity can be removed by skimming and settling and the sirup has a pleasanter flavor and keeps better. The proper liming of sorghum juice is so difficult that most sirup makers do not practice it. The few who do take care to employ too little lime. This practical difficulty in properly neutralizing the acids in sorghum juice has long stood in the way of progress in sirup manufacture. The use of lime or of an equivalent substance appears essential to the production of an improved quality of sirup. Glucose makers have a saccharine liquid containing dilute acid which it is necessary to neutralize. They can not use lime, because quicklime injures their liquid, as it also injures sorghum juice. They remove all traces of the acid by adding, at intervals of ten or fifteen minutes, powdered carbonate of lime, limestone, marble, or chalk, in small quantities, stirring the liquid slowly and continuously for a considerable time. If its action should be the same in sorghum juice as it is in glucose liquor, there would be very great advantages in using carbonate of lime instead of free lime. It is cheap, used in excess it is not harmful, and it does not give sirup the flavor which limed sorghum sirup has. It does not change by keeping, and the acids could, practically, be more perfectly neutralized than can be done by caustic lime. Until further experimental work has been done, sorghum-sirup makers should use lime sparingly, about a pint of milk of lime (not cream of lime), like whitewash, in 50 gallons of juice. The limed juice, after thorough mixing, should slightly redden a piece of litmus paper.* It seems preferable to lime the juice before heating.

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* Red and blue litmus paper can generally be purchased at drug stores. Alkaline liquids, as lime water, turn red litmus blue; acid liquids, as vinegar, turn blue litmus red.

SKIMMING, SETTLING, AND FILTERING.

As a rule, sorghum-sirup makers are careful to remove by skimming the impurities which rise when the juice is heated, but are not careful to remove by settling the heavier impurities, and they never remove by filtration those which neither rise nor settle, but remain suspended in the juice. Cane-sugar makers, beet-sugar makers, glucose makers, and sugar refiners, brewers, cider and wine makers, all pay much more attention to settling and filtering. Sugar makers and refiners have reason to hurry their processes, since sugar becomes more or less uncrystallizable by long standing; but they nevertheless take time enough to settle and to filter their liquids well. Inversion is not detrimental in sorghum-sirup manufacture, since it hinders the sirup from crystallizing. There is a very general impression among sorghum-sirup makers that it is necessary to "rush the juice." The reverse is true before heating begins and until fermentation threatens. There seem to be advantages in settling the cold juice and removing starch grains, slime, and suspended matters at first instead of cooking them in the juice. There are some impurities in sorghum juice which are insoluble in cold, but become soluble in hot juice. Starch is one of these impurities, and it is believed that the soluble starch formed when starch is heated in the juice gives a peculiar flavor to sorghum sirup. Sorghum juice often does not settle well, either when cold or hot. The impurities which the sirup maker leaves in the sirup go to the table of the consumer. It seems apparent that the way to improve the quality of sorghum sirup is to treat the juice so as to cause the impurities to become insoluble, and permit easy filtration or good settling. Then skim off the lighter impurities, settle out the heavier ones, and remove those which neither rise nor settle by weighting them, so as to cause them to settle, or by adding some substance which coagulates and causes them to rise, or by filtering the juice. At present the sirup makers generally have only the simplest appliances. They can use only the simplest processes, and only those processes of clarification will be discussed here.

The most efficient means for clarifying saccharine liquids known consists in adding to the cold juice some liquid substance which coagulates or becomes solid by heating, and then heating the mixture. The particles of solid substances which are thus formed attract and adhere to the suspended matters, and both the added substance and the suspended matters may then be removed; or in adding two substances which combine in the liquid and form a solid compound, the particles of which also attract and adhere to the solid impurities, so that both may be removed by settling or filtering. Beet-sugar makers all add lime, then inject carbonic-acid gas into the juice, forming solid carbonate of lime, which is insoluble and which greatly assists in the removal of the impurities. The addition of lime and of carbonic-acid gas is made twice, sometimes three times, to beet juice. At present this method of clarification, which is so successful in clarifying beet juice, is not practicable in sorghum-sirup manufacture. Cane-sugar makers and sugar refiners often add lime and superphosphate of lime to their liquids, forming solid phosphate of lime in the juice, which attracts and adheres to the solid impurities of the liquid, so that both may be removed. Much work has been done on this process in sorghum manufacture. It greatly increases the purity of the juice, but it requires care. If too much lime be used, the sirup is injured. If too much superphosphate of lime or acid phosphate of calcium, as it is sometimes called, be used, the impurities of the juice redissolve, the liquid is cloudy, and the sirup is too acid.

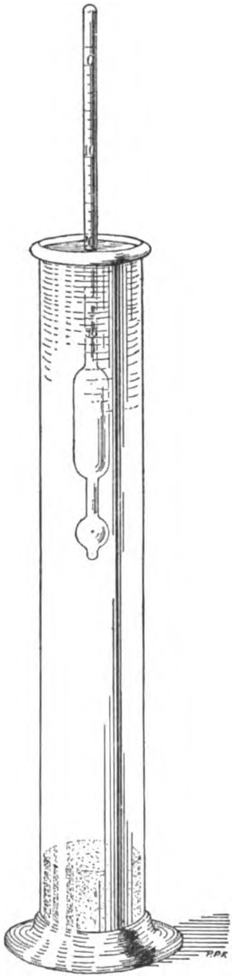
Fig. 5.—Jar and spindle used for determining the density of sorghum juice and sirup.

CLAYING THE JUICE.

The simplest practicable way of partially clarifying sorghum juice known to the writer consists in adding clay to it in order to weight and carry down the suspended impurities which do not rise as scum, and which settle slowly or not at all. This process is not new, having been used many years ago in sugar cane and in sorghum manufacture. It is an imperfect process, but when properly applied it gives better sirup than merely boiling and skimming the juice. In an extreme case, sorghum cane taken from a pile in April gave impure, strongly acid juice, the density of which was 18° Brix. When limed, the density was 18.5° Brix. After clay had been added and well mixed with the juice, the density was 21° Brix, and after settling the density was 15° Brix. Without the aid of heat the process had removed one-sixth of the total solids of the juice. This process requires the use of a suitable clay, sufficient time for settling, and proper care in keeping the settling tanks clean, sweet, and free from fermentation. The use of lime, when not in excess, is an advantage, but is not essential. It promotes the separation of the impurities of the juice and also facilitates the settling of the clay by causing the particles to "flocculate;" that is, to adhere together and form compound grains which settle more readily. Usually a fair quality of clay can be found by testing clays from different localities. It often varies much, in respect to the fineness of the grains, within a small range. Some clays have particles so small that they settle very slowly, leaving water cloudy for days. Such clays are often almost impervious to water and are chosen for making embankments or dams, but require much longer time in settling from sorghum juice than coarser grained clays. The best clays for settling juice seem to be the brown, yellow, or gray varieties, neither too fine nor too coarse grained, and when sand is present larger quantities should be added to the juice. Many clays consist of a mixture of fine and of coarser grained clays. The coarser particles setttle first and the finer particles last, the juice being cloudy longer than when clay is used which contains only the coarser grains. Some clays are of grains of uniform size and such settle clearly, the line between the clear juice and the settling clay being clearly defined. With such clay the liquid at the surface can be drawn off while the juice a short distance below the surface is still settling; for the settling is complete so far as it has progressed. Ten pounds of dry clay, free from sand, is usually sufficient for 50 gallons of juice, though more may be used. It is well to moisten the clay a few days before using, so as to soften hard lumps, and also to mix or work the clay to the consistence of thin mortar in a box similar to that used in making lime mortar. It is then distributed very quickly and evenly in the juice. After adding the clay the juice should be stirred until the foam becomes white. Then the juice should be left

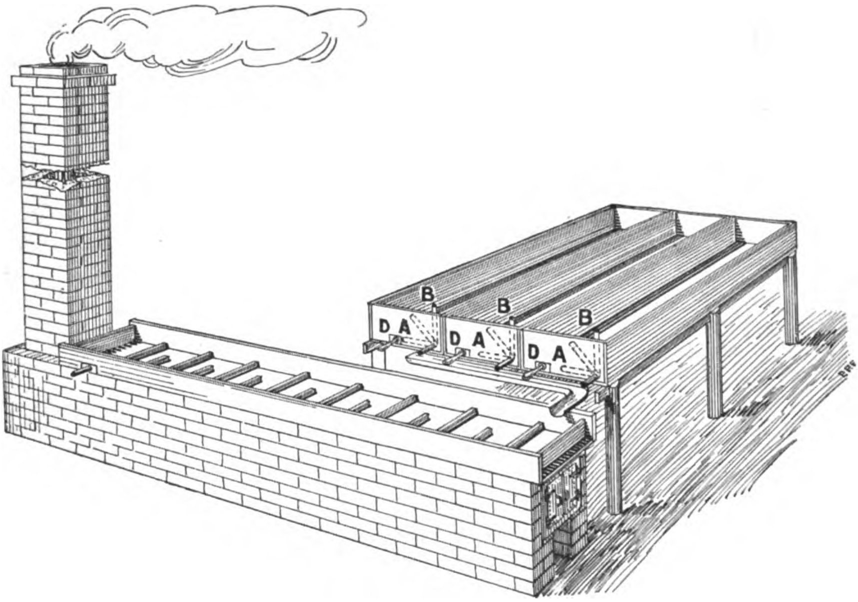

FIG. 6.—Settling tanks for cold clarification.

to settle. When cold, raw juice is treated with clay, three settling tanks are needed; one tank being filled with juice from the mill and one tank used for settling, while the drawing off of the clear juice goes on in the third. Fig. 6 represents an arrangement of settling tanks, A A A for cold settling. When lime is used, about a pint of milk of lime of the consistence of whitewash is put in one of the settling tanks, which is filled, or partly filled with juice, for each 50 gallons of juice contained in the tank and well mixed with the juice. The thin clay mortar is then added and is also well mixed with the juice, stirring until the foam becomes white. The juice is then left to settle, and the same process is used fcr the second and for the third tank as soon as each contains enough juice. When settled, a swing pipe B is turned partly down so that its upper end is below the surface of the mixture. The settled juice near the surface is then drawn off, leaving the turbid liquid and sediment. If desired, the sediment may be emptied through the washout plug D into a tub beneath the settling tank, where it may be re-settled. The settling tank should then be washed well in order to avoid fermentation, and it would also be well to rinse the cleaned tank with clear lime water. After turning up again the swing pipe B and replacing the washout plug D the tank is again ready to be filled.

It is often difficult to see how far settling has progressed in the tanks so as to know how far the swing pipe can be turned down without drawing off unsettled juice. A glass tube, 12 to 18 inches long, having not more than a quarter of an inch bore, held in a vertical position and inserted cautiously, so as not to disturb the juice until it reaches the bottom of the settling tank, the upper end of the tube being then closed with the finger, on being withdrawn from the liquid gives a section of the juice as it is in the settling tank and shows how much clear juice may be drawn from the top, as illustrated in fig. 7, *a*. Or a tall bottle of clear glass may be filled with clayed juice as soon as the clayed juice is left to settle. The settling will go on in the bottle the same as in the tank, and will show the proportion of settled juice in the tank, as in fig. 7, *b*.

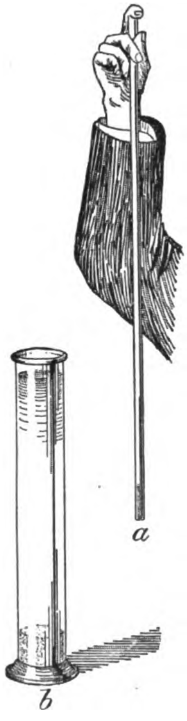

FIG. 7.—*a*. Glass tube used to show how far the juice has settled. *b*. Glass bottle used for same purpose.

Except in quite cool weather, it is not well to let juice stand over night or to leave the tanks uncleaned at night. It is well to give the juice plenty of time to settle – sometimes one hour is enough; sometimes more is required. The kind of clay, the density of the juice, and the temperature influence the time required for settling.

There are some persons who prefer hot clarification of clayed juice. The process is the same as in cold clarification, except that the juice is first heated to near the boiling point, the blanket of scum is removed, and the hot liquid is then clayed and settled as before, as shown in fig. 8. The clearing of hot clayed juice takes less time than that of cold. The writer prefers cold clarification, and, still better, both the cold and the hot clearing, claying the juice twice, the juice being clayed and cleared cold, as shown in fig. 6, then heated, clayed, and cleared again, hot, as shown in fig. 8. As both clearings go on at the same time but little more time is required than for either cold or hot clearing alone. The sirup from juice which was settled cold, also hot, having been clayed twice, is better than that obtained from one settling, and very much better than that obtained from juice which was merely boiled and skimmed without settling.

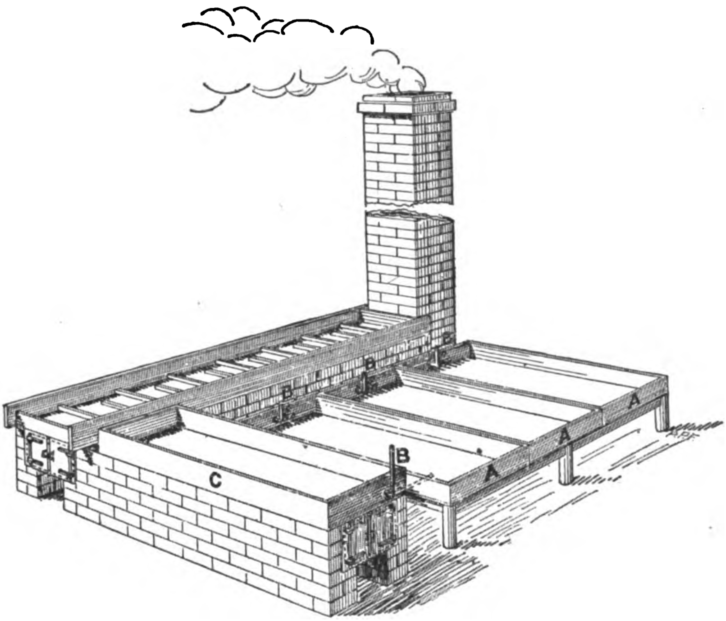

FIG. 8.—Settling tanks for hot clarification.

SETTLING TANKS.

Shallow settling tanks seem best. The juice settles sooner and more closely to the bottom than in deep tanks. They are cheaper, and also easier to clean. Galvanized sheet iron usually comes in sheets 8 feet long and about 30 to 36 inches wide. By making a box the exact size of the sheet iron, from boards 14 or 16 inches wide, and nailing the sheet iron on for the bottom, a cheap and serviceable settling tank is had, holding 150 gallons or more of juice. In nailing the sheet-iron bottom on, it is better to drive the nails far apart at first, then divide and subdivide the spaces by nailing, and not to begin nailing at one point and nail closely around. The reason for this is that each nail stretches the iron a little, and when the stretch of the iron is all at one place a bag, or bad place, is found at the finish of the nailing. The washout opening D, fig. 6, for cleaning the tank, is about 2 inches square, tapering a little from the outside, being a little smaller on the inside, with a well-fitted plug. The swing pipe B, fig. 6, is a contrivance for drawing the liquid from the surface. It consists of a piece of 1¼-inch pipe about as long as the settling tank is deep, a 1¼-inch "elbow," and a "nipple," or short piece of 1¼-inch pipe. When connected together these three pieces form a right-angled pipe, the short arm passing through one end of the settling tank as closely as may be to the bottom. The longer arm is free to turn in the elbow, and, when upright, extends above the surface of the juice in the tank, so that the juice does not escape through the pipe. When the longer arm of the pipe is turned down until its upper end is open to the juice at the surface the clear liquid may be drawn off without disturbing that below. By turning the long arm of the pipe D down level with the bottom of the tank A nearly all the juice flows out. It may be drawn off with this much better and more closely to the sediment, without disturbance, than can be done by pouring or dipping out the settled juice.

It is better to have the swing pipe and the washout plug on one end of the tank. It is well to have the opposite end of the settling tank an inch higher than the end which contains the swing pipe and the washout plug, so that the settled juice may nearly all be drawn off down to the sediment, care being taken not to draw it off farther than it has settled. It is not best to make one end of the settling tank so much higher than the other that the sediment will flow or glide to the lower end when drawing off the juice. The sediment should remain where it settled on the bottom, the clear juice draining from it to the the swing pipe.

It would be well for those who wish to test the cold settling or the hot settling, or both settlings of clayed juice, to try the methods in water or in cane juice in a small way. Or, preferably, to dilute a pint of inferior sirup by adding 5 pints of water, claying, settling, and pouring off the settled liquid and evaporating it to sirup, and compare it with the original sirup. In this manner may be noted the differences in clays in settling quickly, closely, and well, and also the improved clearness of the sirup.

EVAPORATING.

There is perhaps no better evaporating pan for small sirup factories than the old "Cook pan," in which the juice enters the pan at the fire end and passes continuously back and forth, in channels, across the pan to the finishing end. The ledges of this pan serve to keep the bottom nearly level, which is an advantage, for it enables the operator to evaporate a thin sheet of juice instead of a larger quantity. If it were possible to evaporate a film of juice one-fourth of an inch deep without burning, it would produce better sirup than would be made in a pan evaporating a sheet of juice 3 inches deep. The evaporation of films of liquid is now becoming common, even where the evaporation is done in a partial vacuum, at low temperatures. When the juice has been well clarified much less skimming is required during the evaporation, and good sirup can be made in a plain pan which can be removed from the heat as soon as the evaporation has been completed.

SUPERHEATING SORGHUM JUICE.

This method of clarifying seems to promise much for sorghum-sirup makers. It is based upon the theory that a higher heat than that which is now used in clarifying juice, coagulates more of the impurities of the juice; that is, it gives a better clarification. In open pans the temperature can be raised no higher than the boiling point of the liquid, for heat passes off in steam, but in closed vessels under pressure, the steam is retained, and the juice may thus be heated to any desired degree. When juice is heated, some of the impurities rise to the surface when the temperature reaches 150° F., more rise at 180°, and still more rise when the temperature reaches 212°. It is said that when sugar-cane juice is heated under pressure, that is, when it is superheated to 240° F., which is about the temperature of finished sirup when boiling in open pans, it is clarified better, gives no scum, settles more readily, and filters better than juice which has been heated to 212° F. only. It is said that the juice of sugar cane from new, rich, moist land is often impure and difficult to clarify, resembling sorghum juice; and that such juice is better clarified by heating it under pressure to a still higher temperature, as much as 270° F. It is also said that this process is now successfully used in Mexico in small factories which work 50 tons of cane in a day, and also in sugar factories in Louisiana which work 1,200 tons of cane a day. It is further stated that 44 sugar factories in this and in other countries are now using this new method of clarifying sugar-cane juice. High heat accomplishes some things which low heat fails to do, and this method, superheating the juice, may give better clarification of sorghum juice. It should be well tested, in an experimental way, in sorghum-sirup manufacture.

SUMMARY.

The subjects discussed in the foregoing pages may be briefly summarized as follows:

Sorghum is more extensively grown in this country than any other sirup producing plant.

Its juice can be made to produce sirup of as good quality as sugar-cane sirup, or molasses.

The manufacture of sorghum sirup has declined throughout the country because the quality of the product is such that other sirups are preferred by the general public, since it ranks in the Northern markets with the middle grades of Louisiana centrifugal molasses.

By improving the quality of sorghum sirup the demand may be increased, its value raised, and its manufacture extended.

Improvement in the quality of sorghum sirup may be made by selecting varieties of sorghum which are best adapted to sirup manufacture, and also by clarifying sorghum juice in more efficient ways.

Improved methods of clarifying sorghum are needed in all sections where sorghum is grown, but are specially needed in the semiarid sections of the West.

The planting and cultivation of sorghum should be such as to allow full development of the canes.

In grinding cane unnecessary loss of juice may often be avoided by the proper adjustment of the mill.

The quality of sorghum sirup is determined by the more or less perfect separation from the juice of the impurities which are solid and of those which are in solution.

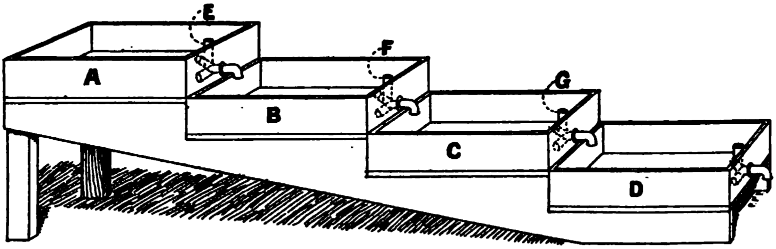

FIG. 9.—Tanks for cold and hot settling.

The methods recommended are cold settling of raw clayed juice, with or without lime, or settling the heated juice with clay, and with or without lime. The method preferred is to settle cold, limed and clayed juice, draw off and heat the settled juice, clay and settle it, and again draw it off, then evaporate it. These processes are clearly shown in fig. 9, the raw juice being limed, clayed, and settled cold in settling tank A, the settled juice being drawn off by the swing pipe E into the juice heater B, where it is heated to near the boiling point and skimmed; then drawn off by the swing pipe F into the hot settling tank C, where it is again clayed and settled, and the clear juice drawn off by a swing pipe G into the evaporator or receiving tank D. The clarified juice is then evaporated to sirup. By this method most of the solid impurities which were in suspension in the juice are removed.

In fig. 9 the tanks A, B, C, and D illustrate simply the principle of transferring the juice by gravity. In practice the tanks B, C, and D are separated from A and are supplied with a source of heat, either steam or open fire.

Evaporating the juice is best done as shallow as possible without burning. It should be done quickly, and the sirup should be cooled as soon as possible. With well-clarified juice good sirup can be made in a plain pan, which may be removed from the fire when the sirup is finished.

Sirup, or rather semisirup, so made can be further clarified by an additional process which refines the semisirup by removing impurities in solution, so that it is equal to the best cane sirup.

The additional processes of clarification require further practical experimental work to adapt them to the use of those who manufacture sorghum sirup on a small scale. It is believed that a process for removing the impurities in solution in the juice, after the solid impurities have been removed, may be developed, and that the process may be adapted to those who manufacture sirup on a small scale, so that they may produce a finished and first-class table sirup free from sorghum flavor.

LETTERS FROM REPRESENTATIVE SIRUP MAKERS.

Mr. Seth H. Kenny, of Minnesota, a sorghum-sirup maker of forty years' experience, states:

I have grown the Minnesota Early Amber eighteen successive seasons. We make 10,000 to 15,000 gallons of sirup yearly. We grow cane, and also buy 1,000 to 1,200 tons yearly, at $2 per ton. Last season the average number of gallons of sirup made each day of ten hours was 415. In a previous season we made 15,650 gallons from 94 acres. The average cost of growing cane and hauling it half a mile to the mill was 10 cents per gallon of sirup manufactured. The average cost of making the sirup was 9 cents a gallon. Two pounds of seed are required for an acre. The plants should be thinned. It is important to cultivate cane well when small. When the seed heads begin to turn brown I begin to grind. I cut cane twenty-four to forty-eight hours ahead of my wants. I know nothing better than lime for defecation and the Porter steam pan for evaporation. The lime is about as thick as whitewash when used. About 1 quart of this milk of lime is used in each 100 gallons of juice. A good sirup can be made without lime—and probably nineteen-twentieths is manufactured in this way—but the use of a quart of milk of lime in 100 gallons of juice is preferable. The use of lime at the right time, in the right place, and in the right quantity requires skill. It is necessary to bring the juice nearly to a boil; skim, draw off into the evaporator, boil rapidly, and cool the sirup quickly. The latter should weigh 11½ to 12 pounds per gallon. The pan should be well cleaned once a day. The tanks, etc., should be clean and sweet.

Abstract from the letter of Mr. C. M. Schwarz, of Illinois, a sirup maker of forty years' experience:

I visited a sirup mill last fall. I found the same operations as forty years ago, and sirup of the same appearance, but not so good in quality. Canes from the size of a pencil to that of one's thumb, some green, some ripe, were used.

The stores take the sirup in exchange, and do the best they can with it. Think what the beet would now be if it had been treated as sorghum has in the past forty years.

My most successful method of manufacture was to pass sulphur fumes into the cold juice a short time in the defecators, then hurry the boiling. The work done by the Department of Agriculture in improving varieties of sorghum produced wonderful results, as I found by planting the improved varieties. I used the Cook evaporator twenty years. There are no better evaporators, but a heater or defecator should also be used; and let the evaporator be made of copper. The sirup maker can obtain sheet copper and make his own pan. The use of copper saves trouble in cleaning; it saves fuel, and besides, a bright pan produces a better sirup. The use of clay has been well spoken of. It never was a success with me. It requires many tanks. The best way to settle cold juice is in a long trough leading from the mill, so arranged as to hold back floating matter and sediment. It should be washed out twice a day. All settling devices which require time are bad; fermentation sets in and the sirup is ropy.

Densmore Brothers, of Minnesota, who have experimented much, state in their letter:

Good defecation is important; evaporation affords no remedy for poor defecation. As it comes from the mill the juice is full of impurities; whatever of these remain in the sirup affect its quality. Many substances have been tried in the defecation but the invariable conclusion is a return to lime. It neutralizes the acids and cuts the gummy matter. It is a necessity to remove impurities from the juice before evaporation begins. In defecating, the juice should be heated to near boiling, then the heat should be shut off and the impurities be allowed to separate as gum and sediment. Three defecators should be used; one being filled, one settling, one being drawn from. An automatic swing pipe drains the juice from near the surface to the evaporator, where there is a valve for regulating the supply. When not in use the swing pipes are turned up to full height, so as not to act. The outlets from the defecators all connect with a pipe which conveys juice to the evaporator. Sorghum sirup is far behind the times, and it will not be satisfactory until sirup makers use up-to-date methods.

Mr. J. P. Wherry, of Missouri, writes as follows:

The first time I tried clay was in a bucketful of juice without lime. It settled nicely, and I used clay for some time before I began the use of lime. It is best to procure a supply of clay before the grinding season. We have a yellow clay with gray streaks, free from sand, about 3 feet below the surface.

In hot weather cane should be ground in the morning and the juice be converted into sirup before closing the factory at night. In cool weather the juice may stand over night. The settling tanks should be clean and not sour from previous use. I never had juice or sirup ropy. It is best to slack half a bushel of lime in a barrel, fill with water, and use the clear lime water to rinse the tanks, after washing them clean. Add half a pint of milk of lime and a quarter of a bushel of clay to each fifty gallons of juice, stir and mix well. Some lots of juice require more stirring than others.

Mr. W. A. Norton, of Iowa, makes the following statements in his letter:

I have a two-horse mill, double sweep, with horse on each end, with an equalizer. In the factory I have three settling tanks with wooden sides and iron bottoms, 8 feet long, 3 feet wide, and 1 foot deep, set up off the ground, so that the juice runs from them to the evaporator, with back end of the tank raised 2 inches, and the outlet about 2 inches above the bottom. I use no lime nor swing pipe, only an outlet pipe. I mix clay thoroughly with the juice and let it settle one hour. I use two pans, 7 feet and 9 feet long, on same arch. The juice is strained through straw and wire at the mill, and the sirup is strained as it comes from the pan. I can purify juice with clay so that not more than one pailful of scum will rise on both pans in a whole day's run. Clay is a success in sorghum sirup manufacture and does away with the impurities that do not rise. My mill started grinding in the morning, and by the time the juice was settled I had cut enough cane with a McCormick corn harvester to run for the day. The only trouble was some of my sirup sugared. I have made sirup over thirty years and have made 3,000 gallons in one season.

Mr. Jacob George, of Iowa, writes:

I have held my trade with the same wholesale dealer for ten years. Cane should not be planted until the weeds have started well before plowing. Fine the soil well, plant in drills 4 to 6 inches between canes and 3 feet 4 inches between rows. Cultivate as soon as the rows can be followed, then give one good hoeing to clear the row. After this cultivate two or three times with "eagle-claw" shovels.

At first, when the cane is very green, strip the leaves when beginning grinding. I use the Folger steam pan, but no lime, clay, chemicals, nor anything except cane juice. I carry the juice 3 to 4 inches deep in the defecator and 1 to 1½ inches in the finisher. Defecating in vats 3 to 4 feet deep is enough to ruin juice. The less juice and the quicker it is finished the better. I do not filter through straw, but have the juice flow in a wide trough a distance of 40 feet or more, which allows much sediment to settle before the juice reaches the defecator. The raw juice should be started to boil slowly, then increase the boiling and finish with a violent boiling, using not less than 80 pounds of steam, and preferably 100 pounds. The capacity of my factory is 10 barrels a day and I shall double it the coming season. I charge 10 cents a gallon to manufacture sirup when the cane is delivered and find it profitable. About every cane mill here has been in operation, and next season will see more cane planted than ever before.

A sirup and molasses dealer, who has long handled quantities of sorghum sirup, makes the following statements:

Our experience has been wholly in the line of selling, not of refining sirups. Our idea for a standard sirup is that it should weigh 11¼ pounds to the gallon; if heavier it is liable to sugar; if lighter, to ferment. It should be bright in color, with as mild flavor as possible. Any method that will soften the rank flavor and brighten the color of sorghum will materially improve it. We think you are working in the right direction.

Another firm of jobbbers in sirup and molasses writes:

Sorghum has improved very little since it came into prominence. The fact worth mentioning is that your State (Kansas) produces sorghum which has an objectionable flavor. The best suggestion we can offer is, make the sirup as light as possible in color, of good body, and guard against the objectionable flavor.

FARMERS' BULLETINS.

These bulletins are sent free of charge to any address upon application to the Secretary of Agriculture, Washington, D. C. Only the following are available for distribution:

No. 15. Some Destructive Potato Diseases: What They Are and How to Prevent Them. Pp. 8.
No. 16. Leguminous Plants for Green Manuring and for Feeding. Pp. 24.
No. 18. Forage Plants for the South. Pp. 30.
No. 19. Important Insecticides: Directions for Their Preparation and Use. Pp. 20.
No. 21. Barnyard Manure. Pp. 32.
No. 22. Feeding Farm Animals. Pp. 32.
No. 23. Foods: Nutritive Value and Cost. Pp. 32.
No. 24. Hog Cholera and Swine Plague. Pp. 16.
No. 25. Peanuts: Culture and Uses. Pp. 24.
No. 26. Sweet Potatoes: Culture and Uses. Pp. 30.
No. 27. Flax for Seed and Fiber. Pp. 16.
No. 28. Weeds; and How to Kill Them. Pp. 30.
No. 29. Souring of Milk, and Other Changes in Milk Products. Pp. 23.
No. 30. Grape Diseases on the Pacific Coast. Pp. 16.
No. 31. Alfalfa, or Lucern. Pp. 23.
No. 32. Silos and Silage. Pp. 31.
No. 33. Peach Growing for Market. Pp. 24.
No. 34. Meats: Composition and Cooking. Pp. 29.
No. 35. Potato Culture. Pp. 23.
No. 36. Cotton Seed and Its Products. Pp. 16.
No. 37. Kafir Corn: Characteristics, Culture, and Uses. Pp. 12.
No. 38. Spraying for Fruit Diseases. Pp. 12.
No. 39. Onion Culture. Pp. 31.
No. 40. Farm Drainage. Pp. 24.
No. 41. Fowls: Care and Feeding. Pp. 24.
No. 42. Facts About Milk. Pp. 29.
No. 43. Sewage Disposal on the Farm. Pp. 22.
No. 44. Commercial Fertilizers. Pp. 24.
No. 45. Some Insects Injurious to Stored Grain. Pp. 32.
No. 46. Irrigation in Humid Climates. Pp. 27.
No. 47. Insects Affecting the Cotton Plant. Pp. 32.
No. 48. The Manuring of Cotton. Pp. 16.
No. 49. Sheep Feeding. Pp. 24.
No. 50. Sorghum as a Forage Crop. Pp. 24.
No. 51. Standard Varieties of Chickens. Pp. 48.
No. 52. The Sugar Beet. Pp. 48.
No. 53. How to Grow Mushrooms. Pp. 20.
No. 54. Some Common Birds in Their Relation to Agriculture. Pp. 40.
No. 55. The Dairy Herd: Its Formation and Management. Pp. 24.
No. 56. Experiment Station Work—I. Pp. 30.
No. 57. Butter Making on the Farm. Pp. 15.
No. 58. The Soy Bean as a Forage Crop. Pp. 24.
No. 59. Bee Keeping. Pp. 32.
No. 60. Methods of Curing Tobacco. Pp. 16.
No. 61. Asparagus Culture. Pp. 40.
No. 62. Marketing Farm Produce. Pp. 28.
No. 63. Care of Milk on the Farm. Pp. 40.
No. 64. Ducks and Geese. Pp. 48.
No. 65. Experiment Station Work—II. Pp. 32.
No. 66. Meadows and Pastures. Pp. 24.
No. 67. Forestry for Farmers. Pp. 48.
No. 68. The Black Rot of the Cabbage. Pp. 22.
No. 69. Experiment Station Work—III. Pp. 32.
No. 70. The Principal Insect Enemies of the Grape. Pp. 24.
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No. 72. Cattle Ranges of the Southwest. Pp. 32.
No. 73. Experiment Station Work—IV. Pp. 32.
No. 74. Milk as Food. Pp. 39.
No. 75. The Grain Smuts. Pp. 20.
No. 76. Tomato Growing. Pp. 30.
No. 77. The Liming of Soils. Pp. 19.
No. 78. Experiment Station Work—V. Pp. 32.
No. 79. Experiment Station Work—VI. Pp. 28.
No. 80. The Peach Twig-borer—an Important Enemy of Stone Fruits. Pp. 16.
No. 81. Corn Culture in the South. Pp. 24.
No. 82. The Culture of Tobacco. Pp. 23.
No. 83. Tobacco Soils. Pp. 23.
No. 84. Experiment Station Work—VII. Pp. 32.
No. 85. Fish as Food. Pp. 30.
No. 86. Thirty Poisonous Plants. Pp. 32.
No. 87. Experiment Station Work—VIII. Pp. 32.
No. 88. Alkali Lands. Pp. 23.
No. 89. Cowpeas. Pp. 16.

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V. P. P.—64.

U. S. DEPARTMENT OF AGRICULTURE.

FARMERS' BULLETIN No. 91.

POTATO DISEASES AND THEIR TREATMENT.

BY

B. T. GALLOWAY,
Chief of the Division of Vegetable Physiology and Pathology.

1862 1889

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1899.

LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Division of Vegetable Physiology and Pathology,
Washington, D. C., February 15, 1899.

Sir: I respectfully submit herewith a paper on potato diseases and their treatment, and recommend its publication as a Farmers' Bulletin. I am indebted to Prof. L. R. Jones, of the Vermont Agricultural Experiment Station, for valuable advice in the preparation of the material.

Respectfully,

B. T. Galloway,
Chief of Division.

Hon. James Wilson,
Secretary of Agriculture.

CONTENTS.

Page.
Introduction 5
Potato leaf blight, or early blight 5
  Treatment 5
Potato blight, late blight, or rot 7
  Treatment 8
Brown rot 8
  Treatment 8
Potato scab 9
  Treatment 9
Tip burn, leaf burn, or scald 10
  Treatment 10
Arsenical poisoning of potato leaves 11
Concluding remarks 11

ILLUSTRATIONS.

Page.
FIG. 1.—Characteristic appearance of leaf affected with early blight 6
2.—Late blight, due to *Phytophthora infestans* 7
3.—Brown rot of the potato 8
4.—Potato affected with scab 9

POTATO DISEASES AND THEIR TREATMENT.

INTRODUCTION.

A number of diseases affect the Irish potato in this country, and the losses they occasion are often a serious drain on the farmer's income. The object of this bulletin is to briefly describe the most important diseases and to outline methods of treatment which experience has shown to be successful in holding them in check.

POTATO LEAF BLIGHT, OR EARLY BLIGHT.

(*Alternaria solani* (E. & M.) Sorauer.)

This disease is widespread and destructive. It is confined to the leaves and green stems, and appears about the time the tubers begin to form, but may be noticed earlier if the growth of the plants has been checked in any way. The first indication of its presence is the appearance on the leaves of grayish brown spots, which soon become hard and brittle. The disease progresses rather slowly, the spots gradually becoming larger, especially along the edges of the leaflets. At the end of ten days to two weeks half of the leaf surface may be brown, withered, and brittle (fig. 1), while the rest is of a yellowish green color. Three weeks or a month may elapse before all the leaves succumb. The stems in the meantime remain green, but they too finally perish through lack of nourishment. The tubers stop growing almost as soon as the leaves are attacked, and as a result the crop is practically worthless.

TREATMENT.

Early blight may be held in check by the application of the fungicide Bordeaux mixture. This is prepared and applied as follows: Pour into a 50-gallon barrel 25 gallons of clean water; then weigh out 6 pounds of crushed bluestone, or copper sulphate, and after tying it in a piece of coarse sacking suspend the package just beneath the surface of the water by means of a string tied to a stick laid across the top of the barrel. In another suitable vessel, such as a tub or half barrel, slack 4 pounds of fresh lime. Slack the lime carefully by pouring on small quantities of water at a time, the object being to obtain a smooth, creamy liquid, free from grit. When the lime is slacked add sufficient water to make 25 gallons. As soon as the bluestone is dissolved, which will require an hour or more, pour the lime milk and bluestone solutions together, using a separate barrel for the purpose and stirring constantly to effect a thorough mixing. It sometimes happens that sufficient lime is not added, and as a result the foliage may be injured. To be certain that the mixture is safe, hold a steel knife blade in it for two or three minutes, and if the polished surface of the blade shows a copper-colored tinge add more lime, but if it stays bright the mixture is safe to use. Application of the mixture should begin when the plants are 4 to 6 inches high, and should be repeated at intervals of twelve to fourteen days until five or six treatments have been made. By adding 8 ounces of Paris green to each barrel of the Bordeaux mixture a combined fungicide and insecticide is obtained, and this will prevent the attacks of the Colorado potato beetle, the flea beetle, and other insects. Before adding the Paris green it should be mixed with a small quantity of water, and when a thin paste is obtained this should be thoroughly stirred into the barrel of Bordeaux solution.

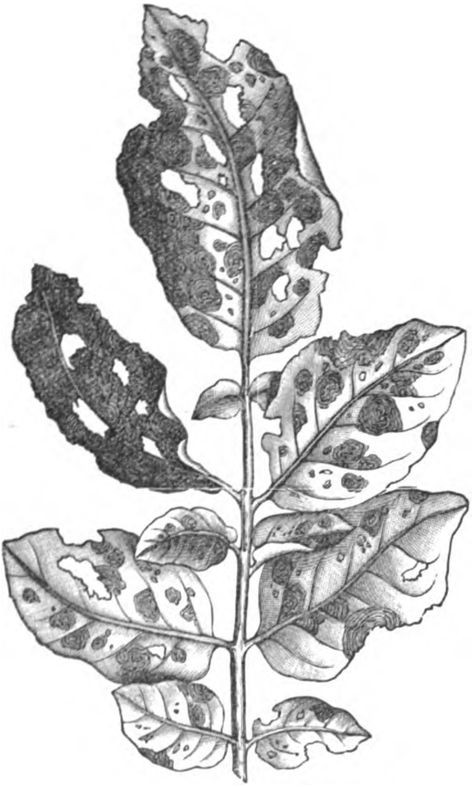

FIG. 1.—Characteristic appearance of leaf affected with early blight.

The success attending the application of the Bordeaux mixture depends in large measure upon the thoroughness with which it is applied. To reach all parts of the plants above ground with a fine spray requires a good force pump and a suitable nozzle. The knapsack sprayer, now on sale in nearly every section of the country, will be found one of the most useful machines for spraying fields of 3 acres or less. For larger plantations more powerful machines should be used. A cheap and serviceable apparatus, well suited for this work, may be made by mounting a good, strong force pump on a barrel, and then placing the barrel and mounted pump in a light wagon. The entire outfit, including barrel, pump, hose, nozzles, operator, and boy to drive, may be drawn by one horse. As the wagon is drawn slowly between the rows the man in the wagon may operate the pump and at the same time keep the mixture stirred, while two others on the ground hold the nozzles and direct the spray over the plants. The nozzle found to be best suited to the work is the Vermorel. This is now offered for sale by pump manufacturers and dealers in seeds and agricultural implements in various parts of the country. Where there are only a few plants to treat, simple devices for the application of the fungicide, such as watering cans, the syringes used by florists, etc., may be used.

POTATO BLIGHT, LATE BLIGHT, OR ROT.

(*Phytophthora infestans* (Mont.) de By.)

This disease attacks the leaves, stems, and tubers. Generally the first noticeable effect upon the leaves is the sudden appearance of brownish or blackish areas, which soon become soft and foul smelling. So sudden is the appearance of the disease in some cases, that fields which one day look green and healthy may within the next day or two become blackened as though swept by fire. The rapid spread of the disease, which is caused by a parasitic fungus, is dependent in large measure upon certain conditions of moisture and heat. A daily mean or normal temperature of from 72° to 74° F. for any considerable time, accompanied by moist weather, furnishes the best conditions for the spread of the parasite. On the other hand, if the daily mean or normal temperature exceeds 77° for a few days, the development of the disease is checked. This fact explains why the fungus seldom occurs to any serious extent in sections where the mean or normal daily temperature exceeds 77° for any length of time, and probably why it appears later than the disease discussed under the former heading. The tubers affected with the disease show depressed, dark-colored areas on the surface (fig. 2 *2*), while within are blotches and streaks of a brownish or blackish color. Other diseases may produce similar effects, so that in this case the changes are not so characteristic as those shown by the leaves. For many years it was believed that most of the injury to the potato was due to this disease, but recent investigations have shown that view to be erroneous.

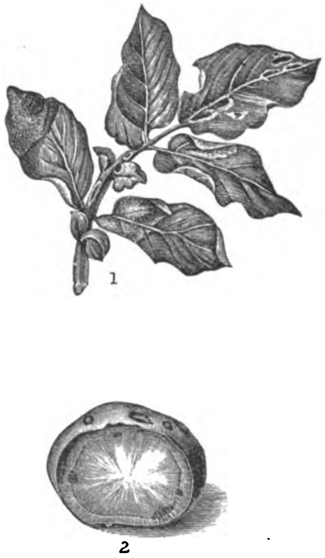

FIG. 2.—Late blight, due to *Phytophthora infestans*: *1*, Blight of the foliage; *2*, discoloration and rotting of the tuber.

TREATMENT.

The same treatment as recommended for early blight should be followed here, and will be found to prevent the blighting of the tops and rotting of the tubers. In regions where late blight is known to occur, care should be taken to begin the application of the Bordeaux mixture before the attacks of the fungus. In all this work it must be constantly kept in mind that the main object is prevention rather than cure. Benefit will undoubtedly result if only clean, healthy potatoes are used as seed. Decayed and discolored tubers should be fed to the hogs, as it is poor policy to plant them.

BROWN ROT.

(*Bacillus solanacearum* Smith.)[1]

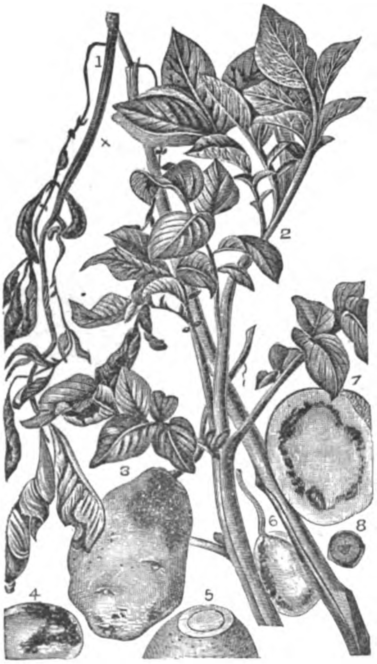

FIG. 3.—Brown rot of the potato: Wilting of stem and leaves and browning of tubers.

This disease occurs in many parts of the South, and, in addition to attacking the potato, is found to seriously injure eggplants and tomatoes. In the case of the potato, the leaves, stems, and tubers are affected. The disease usually manifests itself by a sudden wilting of the foliage and soon the whole plant may become affected, the leaves and stems shriveling and then turning brown or black (fig. 3). The disease reaches the tubers through the stems, producing a brown or black discoloration of the tissues and ultimately a complete breaking down or rotting of all the parts. Brown rot is caused by a bacillus, a minute organism, which multiplies in the tissues and through its action produces the effects mentioned. Various insects, such as Colorado beetles, flea beetles, and blister beetles, serve as carriers of the disease. These insects may feed on a diseased plant, and in their visits to adjoining healthy ones infect the tissues through bites and possibly in other ways.

TREATMENT.

Throughout the South, namely, in South Carolina, Mississippi, Alabama, and adjacent States where this disease is known to occur, a thorough system of spraying, such as recommended for early blight, should be followed. In addition, all diseased vines should be removed and destroyed as soon as possible, and the tubers should be dug and either used at once or stored in a cool, dry place. In planting it would be well to avoid land which has just been used for tomatoes or egg-plants, and finally seed tubers from localities where the disease is absent should be used if practicable.

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[1] Smith, Erwin F., Bull. No. 12, 1896, Division of Vegetable Physiology and Pathology.

POTATO SCAB.

(*Oospora scabies* Thaxter.)

Scab is one of the most widespread diseases affecting the potato. Injuries of various kinds may produce a roughened surface, but it is safe to say that most of what is known as scab is due to the attacks of a minute parasitic fungus, first studied and described by Dr. Roland Thaxter, of Harvard University. The effects of the disease on the tuber are so characteristic that figure 4 will, we believe, enable any one to identify it.

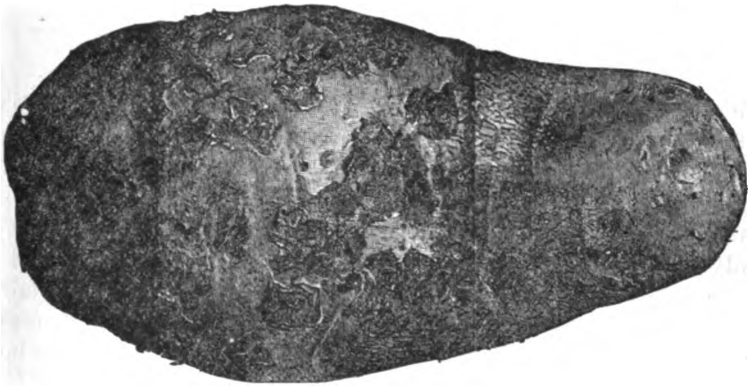

FIG. 4.—Potato affected with scab.

TREATMENT.

Potato scab may be successfully controlled by treating the seed previous to planting. Two fungicides are used for the purpose, namely, corrosive sublimate solution and formalin solution. To prepare the first, dissolve 2½ ounces of corrosive sublimate, or bichloride of mercury, in about 2 gallons of hot water and after ten or twelve hours dilute with clear water so that the whole quantity makes 15 gallons. Corrosive sublimate is a poison and must therefore not be placed where it can fall into the hands of children or irresponsible persons. To prepare the formalin solution, mix 8 fluid ounces of commercial formalin (otherwise known as 40 per cent formic aldehyde) with 15 gallons of water.

To treat the potatoes with the corrosive sublimate solution, immerse them for an hour and a half in the liquid and then spread out to dry.

Finally cut and plant in the usual manner. A large barrel is a convenient receptacle for the solution. The potatoes may be placed in a coarse sack and suspended in the liquid, care being taken to wash the tubers before dipping, provided they are very dirty. All treated tubers should be planted in order to avoid danger from the poison upon them.

It has been shown that the formalin is fully as effective against scab as the corrosive sublimate solution, and as it is far less dangerous it will probably come into more general use. In treating seed with this preparation the whole potato should be soaked for two hours in the solution already described. After soaking, the potatoes may be dried, cut, and planted in the usual way, care being taken not to allow them to become contaminated by coming in contact with bags, boxes, or bins where scabby potatoes have been kept. In practice it is found that 15 gallons of either of the foregoing solutions will be sufficient to treat 20 to 25 bushels of potatoes, taking ordinary precautions of course not to waste too much of the fluid as each lot of tubers is dipped.

TIP BURN, LEAF BURN, OR SCALD.

This disease of the leaves occurs in many parts of the country and is often confused with early blight. The tips and edges of the leaves turn brown and these discolored areas soon become hard and brittle.

The burning or scalding may occur at any time and as a rule is the result of unfavorable conditions surrounding the plant. Long-continued cloudy and damp weather followed by several hot and bright days is very apt to result in the burning of the foliage. This is especially the case on soils carrying a comparatively small percentage of moisture. When the weather is cloudy and damp the tissues of the potato become gorged with water and this has a tendency to weaken them. If the sun appears bright and hot when the leaves are in this condition, there is a rapid evaporation of the moisture stored up in their cells. The evaporation may be faster than the supply furnished by the roots, and if this continues for any length of time the weaker and more tender parts first collapse, then die, and finally turn brown and dry up. Tip burn may also occur as the result of protracted dry weather.

TREATMENT.

Little of a specific nature can be said on the treatment of this trouble. Numerous factors are involved in the matter, so that only general statements are possible. Every effort should be made to keep the plants in good growing condition, for if they become checked through lack of proper food or cultivation or both they are more apt to burn. It is a fact that where the Bordeaux mixture is used for other diseases burn is less apt to occur, and this furnishes another instance of the remarkable properties of the fungicide. Briefly, therefore, the plants should be kept as vigorous as possible by good cultivation, plenty of available food, and the application of Bordeaux mixture, as recommended for early blight.

ARSENICAL POISONING OF POTATO LEAVES.

In many sections where Paris green in water is applied to potatoes injuries are produced which can not be distinguished from early blight by any ordinary examination. It frequently happens, therefore, that farmers are led to believe that their potatoes are affected with early blight and other diseases when the trouble has been brought on by themselves through the improper use of Paris green. Injuries resulting from the use of this substance are very apt to occur where flea beetles have eaten the foliage. The arsenic attacks the tissues at such points, and as a result more or less circular brown spots are produced, having for their centers the holes eaten out by the flea beetles. By combining the Paris green with Bordeaux mixture, as already described, these injuries may be wholly avoided.

CONCLUDING REMARKS.

The cost of the work of spraying as described here will depend to a considerable extent upon the kind of machinery used and the price paid for labor. With suitable apparatus and labor at $1.50 per day, potatoes may be sprayed six times for about $6 per acre. This estimate is based upon experiments extending over several years and includes the cost of chemicals as well as labor. The cost of treating scab is mainly in the labor involved in dipping and drying the seed and seldom exceeds 15 cents per acre. Much attention has been given to the effects of Bordeaux mixture on the growth and yield of potatoes aside from its value in keeping parasitic foes in check. It has been shown conclusively that it pays to apply this preparation if for no other purpose than to induce a more vigorous growth. Three or four applications of the mixture have in many cases increased the yield of potatoes 50 per cent, so that no matter where the crop is grown or whether diseases are present or not the writer feels warranted in recommending the application of the mixture on the ground that its use will yield a handsome return.

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The following is a list of the Farmers' Bulletins available for distribution, showing the number, title, and size in pages of each. Copies will be sent to any address on application to Senators, Representatives, and Delegates in Congress, or to the Secretary of Agriculture, Washington, D. C.:

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58. The Soy Bean as a Forage Crop. Pp. 24.
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60. Methods of Curing Tobacco. Pp. 16.
61. Asparagus Culture. Pp. 40.
62. Marketing Farm Produce. Pp. 28.
63. Care of Milk on the Farm. Pp. 40.
64. Ducks and G [illegible] Pp. 48.
65. Experiment [illegible] Work—II. Pp. 32.
66. Meadows a [illegible] s. Pp. 28.
67. Forestry for [illegible] Pp. 48.
68. The Black Rot of the Cabbage. Pp. 22.
69. Experiment Station Work—III. Pp. 32.
70. Insect Enemies of the Grape. Pp. 23.
71. Essentials in Beef Production. Pp. 24.
72. Cattle Ranges of the Southwest. Pp. 32.
73. Experiment Station Work—IV. Pp. 32.
74. Milk as Food. Pp. 39.
75. The Grain Smuts. Pp. 20.
76. Tomato Growing. Pp. 30.
77. The Liming of Soils. Pp. 19.
78. Experiment Station Work—V. Pp. 32.
79. Experiment Station Work—VI. Pp. 28.
80. The Peach Twig-borer. Pp. 16.
81. Corn Culture in the South. Pp. 24.
82. The Culture of Tobacco. Pp. 24.
83. Tobacco Soils. Pp. 23.
84. Experiment Station Work—VII. Pp. 32.
85. Fish as Food. Pp. 30.
86. Thirty Poisonous Plants. Pp. 32.
87. Experiment Station Work—VIII. Pp. 32.
88. Alkali Lands. Pp. 23.
89. Cowpeas. Pp. 16.
90. The Manufacture of Sorghum Sirup. Pp. 32.
91. Potato Diseases and Their Treatment. Pp. 12.
92. Experiment Station Work—IX. Pp. 30.
93. Sugar as Food. Pp. 27.
94. The Vegetable Garden. Pp. 24.
95. Good Roads for Farmers. Pp. 47.
96. Raising Sheep for Mutton. Pp. 48.
97. Experiment Station Work—X. Pp. 32.
98. Suggestions to Southern Farmers. Pp. 48.
99. Three Insect Enemies of Shade Trees. Pp. 30.
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103. Experiment Station Work—XI. Pp. 32.
104. Notes on Frost. Pp. 24.
105. Experiment Station Work—XII. Pp. 32.
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123. Red Clover Seed: Information for Purchasers. Pp. 11.
124. Experiment Station Work—XVII.
125. Protection of Food Products from Injurious Temperatures. Pp. 26.
126. Farm Buildings.
127. Important Insecticides.
128. Eggs and Their Uses as Food.
129. Sweet Potatoes.
130. The Mexican Cotton Boll Weevil.

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283

U. S. DEPARTMENT OF AGRICULTURE.

FARMERS' BULLETIN No. 92.

Experiment Station Work,

IX.

SUGAR BEETS ON ALKALI SOILS.
PLANTING AND REPLANTING CORN.
IMPROVEMENT OF SORGHUM.
IMPROVED CULTURE OF POTATOES.
SECOND-CROP POTATOES FOR SEED.
COLD v. WARM WATER FOR PLANTS.
FORCING HEAD LETTUCE.
THE DATE PALM IN THE UNITED STATES.
THE CODLING MOTH.
JERUSALEM ARTICHOKES FOR PIGS.
FEEDING CALVES.
PASTEURIZATION IN BUTTER MAKING.
GASSY AND TAINTED CURDS.
PURE CULTURES IN CHEESE MAKING.

PREPARED IN THE OFFICE OF EXPERIMENT STATIONS.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1899.

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I. (Farmers' Bul. 56).—Good v. Poor Cows; Corn v. Wheat; Much v. Little Protein; Forage Crops for Pigs; Robertson Silage Mixture; Alfalfa; Proportion of Grain to Straw; Phosphates as Fertilizers; Harmful Effects of Muriate of Potash; Studies in Irrigation; Potato Scab; Barnyard Manure.

II. (Farmers' Bul. 65).—Common Crops for Forage; Stock Melons; Starch in Potatoes; Crimson Clover; Geese for Profit; Cross Pollination; A Germ Fertilizer; Lime as a Fertilizer; Are Ashes Economical? Mixing Fertilizers.

III. (Farmers' Bul. 69).—Flax Culture; Crimson Clover; Forcing Lettuce; Heating Greenhouses; Corn Smut; Millet Disease of Horses; Tuberculosis; Pasteurized Cream; Kitchen and Table Wastes; Use of Fertilizers.

IV. (Farmers' Bul. 73).—Pure Water; Loss of Soil Fertility; Availability of Fertilizers; Seed Selection; Jerusalem Artichokes; Kafir Corn; Thinning Fruit; Use of Low-grade Apples; Cooking Vegetables; Condimental Feeding Stuffs; Steer and Heifer Beef; Swells in Canned Vegetables.

V. (Farmers' Bul. 78).—Humus in Soils; Swamp, Marsh, or Muck Soils; Rape; Velvet Bean; Sunflowers; Winter Protection of Peach Trees; Subwatering in Greenhouses; Bacterial Diseases of Plants; Grape Juice and Sweet Cider.

VI. (Farmers' Bul. 79).—Fraud in Fertilizers; Sugar-beet Industry; Seeding Grass Land; Grafting Apple Trees; Forest Fires; American Clover Seed; Mushrooms as Food; Pigs in Stubble Fields; Ensiling Potatoes; Anthrax.

VII. (Farmers' Bul. 84).—Home-mixed Fertilizers; Forcing Asparagus in the Field; Field Selection of Seed; Potatoes as Food for Man; Corn Stover as a Feeding Stuff; Feeding Value of Sugar Beets; Salt-marsh Hay; Forage Crops for Pigs; Ground Grain for Chicks; Skim Milk for Young Chickens; By-products of the Dairy; Stripper Butter; Curd Test in Cheese Making; Gape Disease of Chickens.

VIII. (Farmers' Bul. 87).—Soil Moisture; Fertility of Soils; Cover Crops for Orchards; Cultivating v. Cropping Orchards; Transplanting Trees; Fecundity of Swine; Food Value of Eggs; Starch from Sweet Potatoes; The Toad as a Friend of the Farmer.

LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
OFFICE OF EXPERIMENT STATIONS,
Washington, D. C., March 15, 1899.

SIR: The ninth number of Experiment Station Work, prepared under my direction, is transmitted herewith with the recommendation that it be published as a Farmers' Bulletin.

Respectfully,
A. C. TRUE,
Director.

Hon. JAMES WILSON,
Secretary of Agriculture.

CONTENTS.

Page.

Sugar beets on alkali soils 5
Planting and replanting corn 6
Improvement of sorghum by selection 7
Improved culture of potatoes 9
Second-crop potatoes for seed 11
Cold *v.* warm water for plants 13
Soils and fertilizers for forcing head lettuce 15
The date palm in the United States 16
Recent studies on the codling moth 19
Jerusalem artichokes for pigs 20
Supplements to skim milk in fattening calves 21
Pasteurization of milk for butter making 23
Gassy and tainted curds 25
Pure cultures of bacteria for cheese making 26
Explanation of terms 28
    Terms used in discussing fertilizers 28
    Terms used in discussing foods and feeding stuffs 28
    Miscellaneous terms 29

EXPERIMENT STATION WORK—IX.[1]

SUGAR BEETS ON ALKALI SOILS.

It is generally concluded from European experience that alkali lands must be classed among the soils least adapted to the successful culture of the sugar beet. Although the sugar-beet industry is just beginning to be established in this country and we have millions of acres of land whose adaptability to the growth of the sugar-beet is unquestioned, it is nevertheless important to ascertain the possibilities of successful sugar-beet culture on alkali soils, inasmuch as the proximity of such soils to beet-sugar factories may make them especially desirable as beet fields. The existence of these conditions in southern California, near the large sugar-beet factory at Chino, and the fact that the beet fields were there rapidly extended with but little regard to the presence of alkali, without seriously injuring the quality of the beet, induced the California Experiment Station to make a study of the effect of different kinds and amounts of alkali in the soil on the growth and quality of sugar beets.

The investigation was made on a 10-acre field located on the border of a tract of alkali land. The tract contained occasional small alkali spots, which, however, did not seem to interfere with its natural growth of wild grasses and sunflowers. This soil was first planted to various grasses and legumes, but as none of these gave promise of a crop the greater part of the tract was again plowed and planted to sugar beets. "These came up quickly, though with a somewhat thin stand, right among the alkali efflorescences, and continued to grow without let or hindrance." The alkali salts did not seem to affect the beets, although they had proved injurious to the grasses and legumes. Different portions of the tract had different amounts and qualities of alkali salts, and to deduce definite conclusions regarding the tolerance of the plants for the several mixtures of salts the tract was divided into plats 50 feet square, which were investigated separately.

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[1] This is the ninth number of a subseries of brief popular bulletins compiled from the published reports of the agricultural experiment stations and kindred institutions in this and other countries. The chief object of these publications is to disseminate throughout the country information regarding experiments at the different experiment stations, and thus to acquaint our farmers in a general way with the progress of agricultural investigation on its practical side. The results herein reported should for the most part be regarded as tentative and suggestive rather than conclusive. Further experiments may modify them, and experience alone can show how far they will be useful in actual practice. The work of the stations must not be depended upon to produce "rules for farming." How to apply the results of experiments to his own conditions will ever remain the problem of the individual farmer.—A. C. TRUE, Director, Office of Experiment Stations.

The author concludes from the results obtained that without question sugar beets of a good quality can be grown on soil containing as much as 12,000 pounds of alkali salts per acre to the depth of 3 feet, provided the average percentage of common salt is not over 0.04 per cent, or 1,500 pounds per acre.

To find out whether the sugar beet can be profitably grown on alkali lands, it is recommended to those interested in such lands to ascertain the total amount of salts in the upper 3 or 4 feet of soil. This may be accomplished by taking an average sample of the soil to that depth by means of a post-hole auger and having the amount of soluble salts contained in it determined. A considerable portion of the salts present in the first 3 or 4 feet of the soil may come to the surface under cultivation and irrigation and may give the soil the appearance of being too heavily impregnated with alkali to grow beets; but, as these experiments indicate, the feasibility of successfully growing sugar beets depends on the total amount of alkali salts present in this upper stratum, and soils with marked alkali efflorescences at the surface may be perfectly capable of profitable sugar-beet culture.

PLANTING AND REPLANTING CORN.

Owing to abnormal weather conditions, the presence of insect enemies, the failure of the seed, and other influences, it often becomes necessary to postpone the planting of corn or to replant the crop. The question which presents itself under such conditions is how the date of planting affects the yield and maturity. Many of the experiment stations have carried on experiments for several years to determine the influence of the time of planting corn on the yield and maturity of the crop, which have thrown much light on this subject.

In experiments at the Indiana Station it was found that the earliest planting (May 1) yielded the largest crop (41 bushels per acre), while the latest planting yielded about one-fourth less (31.7 bushels per acre). The time required for the crop to mature decreased as the time of planting was delayed. A delay of thirty or forty days in planting shortened the time required for the corn to mature from two to three weeks. At the Kansas Station the average results of experiments in this line carried on for two years showed that corn planted in the beginning of May gave the best results, and at the Illinois Station the average results of similar experiments were in favor of the plantings made from May 4 to 18, with tendencies slightly favoring the later dates.

The experiments indicate, therefore, that under favorable conditions there is an advantage in early planting; but in view of the uncertainties of the weather, which is always a controlling factor in the growing of crops, these results must be applied with caution in practice.

As Tracy[1] has pointed out, planting should not begin too early in the season. "Nothing is gained by putting seed into soil which is too cold or too wet to favor germination. It is better to defer the planting a week or ten days than to run the risk of losing it by decay or of having an imperfect stand by planting before the ground is sufficiently dry to work well and warm enough for immediate growth. Every missing plant means a decrease in the yield, and replanting the missing hills is seldom profitable. The replants are surrounded by plants which mature and shed their pollen before the younger silks are formed. The pollination is therefore very imperfect, and the ears on the replants are usually nubbins, which are scarcely worth gathering. When the missing plants amount to from 10 to 20 per cent of the whole, replanting with some earlier maturing variety which will produce its tassels and silks at about the same time as the original planting is often profitable, but will not pay when the misses are less than 10 per cent. When the misses are more than 20 per cent it will pay better to make an entire new planting."

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[1] U. S. Dept. Agr., Farmers' Bul. 81.

IMPROVEMENT OF SORGHUM BY SELECTION.

Attempts were very widely made some years ago in the United States to utilize sorghum for the manufacture of sugar on a commercial scale. The enterprise proved unsuccessful largely because of the uncertain, but usually low, sugar content of the sorghum cane which was then produced. While the attempts to manufacture sugar have been largely, if not entirely, abandoned, "sorghum sirup is made in every State of the Union and in thousands of small mills,"[1] and for this, if for no other reason, the improvement of sorghum as a sugar producer is still a matter of great importance.

For a number of years several experiment stations have conducted experiments with a view to improving the sorghum plant as a sugar producer. In general the method of improvement consisted of planting seed from plants which were found by analysis to be richest in sugar and highest in purity of juice. Recent bulletins of the Delaware Station report the results of attempts to improve sorghum by selection, comparing crops grown at a number of experiment stations since 1887, and discussing the possibilities of sorghum as a commercial source of sugar.

In 1897 and 1898 experimental crops of sorghum under the supervision of the Delaware Experiment Station were grown at the station and at several other places in Delaware and at Cape Charles, Va. Several thousand stocks have been selected and tested.. The facts ascertained relative to each stock were as follows: (1) The length of stock including seed head; (2) the stripped and topped weight of stock, the seed head having been removed at the arrow joint; (3) the specific gravity of the juice; (4) the direct, or single, polarization of the juice. From these data as a basis the following facts were deduced: (1) The percentage of solids in the juice; (2) the sugar content in a unit volume of juice; (3) the percentage of sugar in the juice; (4) the coefficient of purity; (5) the percentage of juice in the stock; (6) the percentage of sugar in the stock; (7) the weight of sugar in the stock; (8) the coefficient of availability; (9) the weight of pure sugar to be crystallized from a ton of stripped cane, such as the sample; and (10) the number of stocks, such as the sample, required to produce 3,000 pounds of pure crystallized sugar. Each fact is considered important in determining the quality of the sorghum and its adaptation to sugar making. The length and thickness of the stock have a direct bearing on the resistance to wind storms, which is very important, since broken-down cane ferments rapidly, and thus sustains a loss in sugar. The weight of the cane is important partly for the reasons just stated, but mainly because heavy stocks are more readily worked and at a smaller cost and give a higher tonnage per acre than light stocks. The percentage of juice in the stock, the total solids in the juice, and the percentage of sugar directly affect the amount of crystallizable sugar.

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[1] U. S. Dept. of Agr. Division of Chemistry Circ. 1.

The table below gives the analytical results of sorghum crops grown at various experiment stations during a number of years. These results are not considered strictly comparable on account of the variable water content, but they show the wide variations in the composition of sorghum. The analyses reported are taken from the best of the season, so that the small percentages in the sugar content are not due to the decline which takes place toward the end of the season.

Comparison of various sorghum crops.

Station reporting and variety tested.	Year.	Sugar in juice.		
		Maximum.	Minimum.	Average.
		Per cent.	*Per cent.*	*Per cent.*
Iowa	1888	14.72	6.67	12.10
Do	1889	14.87	....	13.18
Kansas	1888	16.56	.96	10.63
Do	1889	15.32	8.41	10.53
Kentucky	1887	15.52	5.26	11.15
Do	1888	12.38	1.59	7.11
Louisiana	1886	16.50	5.40	11.92
Minnesota	1891	15.33	8.34	11.76
Mississippi	1890	14.80	4.19	9.60
New Jersey	1887	....	....	9.00
Do	1888	....	....	8.23
New Mexico	1891	15.02	11.71	12.96
Do	1892	21.9	8.00	11.85
New York	1888	....	....	9.02
Do	1889	....	....	10.87
Do	1891	13.33	2.84	9.13
Do	1892	11.87	6.76	10.33
Delaware, Collier	1894	16.00	7.50	13.10
Delaware, Orange	1898	16.08	5.46	11.61
Delaware, Frame's New}	1896	14.40	10.70	12.90
Do	1897	15.96	6.31	11.98
Delaware, Colman	1894	16.60	6.10	12.98
Do	1896	15.20	8.70	12.90
Do	1897	17.84	10.16	14.62
Delaware, McLean (grown in Delaware)	1894	17.40	6.70	13.60
Do	1896	17.10	12.30	15.60
Do	1897	17.85	10.71	15.20
Delaware, McLean (grown in Virginia)	1897	19.05	6.69	15.24
Do	1898	18.78	7.20	14.79
Delaware, Amber (grown in Delaware)	1894	16.00	7.30	12.60
Do	1896	15.00	9.80	13.00
Do	1897	19.19	8.30	15.74
Do	1898	19.50	4.98	15.11
Delaware, Amber (grown in Virginia)	1897	21.50	10.09	18.15
Delaware, Amber (grown in Virginia from heavy seed)	1898	21.24	4.17	16.53
Delaware, Amber (grown in Virginia from light seed)	1898	19.14	7.50	15.81

It will be seen from these results that there are very great variations in the sugar content of the juice. Great differences were also found to exist in the constancy of the sugar content and the length of the season. The analyses show wide fluctuations, even when but a few days elapsed between them. "To what causes these differences may be due, or rather to which cause of many they may be chiefly due, it is not easy to say. * * * There must, of course, be differences of season and of soil more or less favoring or hindering a good crop, yet despite these there has been an unquestionable rise in the quality of the cane, and this must be attributed to judicious selection of seed for propagation."

In discussing the principles of selective propagation the author points out that the consideration of a high sugar content and a high purity only is insufficient and that other qualities, such as size and strength of stock, tonnage per acre, early ripening, and the constancy of the sugar content throughout the season must be taken into account. The object in view is to crystallize the most sugar at the least expense, but the seed which tends toward the attainment of this result is not very easily selected. The ordinary physical tests of seed in fruit propagation are not sufficient here, but an analysis of the juice of the particular plant must be made and the sugar content taken into consideration. The weight of the stocks was found to be influenced largely by environment, and sacrificing a rich sugar content to weight in selection would not be advisable for that reason. "Of the crop all stocks below 12 ounces or, if there be seed enough, all below 16 ounces may well be rejected altogether, and then of the remainder preference should rest on sugar and purity, i. e., available sugar content. A system by which heavy weight of stock should offset low sugar content would hardly lead to profitable results."

It is believed that the task of selecting will become easier as the work is carried on year after year. The selection of cane of good size and weight and promising appearance in general, which is in accordance with nature's survival of the fittest, will produce a plant with sufficient resistance to storms, and when that result has been attained the question remains one of sugar content and purity, or the percentage of available sugar.

IMPROVED CULTURE OF POTATOES.

As a recent bulletin of the New York Cornell Experiment Station shows, the average yield of potatoes in the United States is far below what it should be. This bulletin states that "the average yield of potatoes throughout New York is not more than one-half what it should be and what it would be were better methods practiced." This low yield is not due, as a rule, to poverty of the soil, because "all soils of ordinary fertility contain sufficient potential plant food to produce abundant crops," and a part of this potential plant food can be made available for the use of plants by tillage, and drainage, if necessary.

The experiments of the Cornell Station, which have now covered four seasons, were planned with a view to learning what superior tillage and care would do in the way of unlocking the hoarded fertility of the soil and increasing the yield of the crops.

The soil on which the potatoes were grown has been continuously under crop without fertilizers since the winter of 1893–94, except that cover crops of rye, crimson clover, or wheat, to be turned under in the spring, have as a rule been grown. But the growth of these has necessarily been so small and the cropping so intensive that the soil is beginning to show a deficiency of humus, indicated by its tendency to become hard and compact under beating rains; for "in order to keep a soil permanently in good physical condition, it is absolutely necessary that organic matter be returned in some way, either by green manuring or the use of barn manures."

Notwithstanding this fact, the yields in the Cornell experiments have been much above the average each year. This was as true of 1898 as of previous years, in spite of the additional fact that the latter season was one of severe drought and the soil used in the experiments "is gravelly and porous and especially subject to injurious effects from drought."

It is probable that frequent and deep plowing has done much to bring and keep the land productive. So far as the plowing is concerned all plats have received the same treatment. The land has been turned from two to three times each year, and the pulverizing which has resulted therefrom has liberated sufficient plant food to mature large crops. In addition to the plowing the land has been frequently harrowed and cultivated and the intensive culture which has been given has liberated all the plant food that could be used by the growing crops with the amount of moisture that was present.

A fact clearly brought out by these experiments is that "success with potatoes depends largely upon the preparation given the soil before the potatoes are planted., Plowing should be deep, and at the time of planting the soil should be mellow and loose."

Only first-class marketable potatoes should be used for seed. These should be cut into pieces averaging two strong eyes. "Seed should not be cut for any considerable period before planting. If it becomes necessary to delay planting for some considerable time after potatoes are cut, the cut pieces should be dusted with plaster and spread out in a moderately moist, cool place."

Early planting has usually given best results, but this necessitates careful spraying with Bordeaux mixture and Paris green to protect the plants from diseases and insects. Early and deep planting and frequent and level tillage are especially important in soils like that used in these experiments, which are likely to be seriously affected by drought.

The methods of planting and cultivation used at the Cornell Station in 1898 were as follows:

The pieces were dropped in the furrows directly after the furrows had been opened, one piece being put in a place and at distances 14 inches apart in the row.

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A furrow was opened [with a shovel plow] in the middle of the space left when the first furrows were opened. This served to cover the potatoes, the earth being ridged up directly over the potato row. The planting was done on May 10. The soil was then left undisturbed until May 28. The ridges which were left over the seed potatoes covered them to a depth of about 8 inches. By May 28 the weed seeds which were in the surface soil had germinated and the whole surface was covered with tiny weeds. A spike tooth harrow was fitted with a piece of 2 by 4 scantling placed diagonally across underneath the frame and held in place by the harrow teeth. The harrow thus rigged was used upon the potato plats, being first run lengthwise of the rows and then crosswise. The weight of the driver upon the harrow was necessary in order to make it do the leveling as required. The benefit derived from this treatment was very marked. All weeds were destroyed, the surface crust was broken, all clods and stones were removed from above the row and deposited in the center of the space between rows, the surface was leveled and in every way the conditions were made favorable for the rapid growth of the potatoes, and they appeared above ground in three or four days.

In general it may be said that "on soils which are not well drained, either naturally or artificially, and on clay or clay loam soils, potatoes may be planted somewhat shallow and slight hilling may be practiced with benefit."

If planting is done very early in the spring the ridges may be permitted to remain for ten days to two weeks before harrowing down. If planting is done somewhat late the ridges should be harrowed within one week after planting. In the case of the early planting there is usually enough moisture present so that the ridging may temporarily prove a benefit by enabling the soil to become warm. In the case of late planting all the moisture should be conserved, and this is best done by leveling the ridges.

Harrowing the soil before the plants appear above ground, followed by from six to seven cultivations during the season, is recommended.

SECOND-CROP POTATOES FOR SEED.

In the Southern States potatoes planted in the spring mature early in the summer, and during the hot weather of the season it is difficult to keep the tubers from decaying. Consequently this early crop does not furnish potatoes for the table during winter nor seed for the next season's planting. This difficulty has given rise to the growing of late crops, a practice which has been in vogue in various sections of the South for a number of years. When second-crop potatoes are not grown it becomes necessary to obtain seed from northern sources. The general opinion of the Southern potato grower is that planting second-crop potatoes grown at home is more profitable than planting northern-grown seed. Experiments with second-crop potatoes for seed have been made at several experiment stations and some promising results have been reported, but work in this line has not as yet been followed very extensively and open questions still remain.

The Arkansas Station has recently published the results of experiments with northern-grown seed and second-crop seed which have been in progress for three years. Northern-grown and second-crop seed were planted in the spring of 1894 to compare the respective yields.

The second-crop seed had been grown by the station the preceding fall. Bliss Triumph and Early Rose, which are very popular varieties in the State, were grown in this test. The results were in favor of the crop from the northern-grown seed, which matured several days earlier and produced an average of 20 bushels per acre more of merchantable potatoes than the second-crop seed. Of the total yield of tubers from the northern-grown seed 12.6 per cent were culls, while of the total yield from the second-crop seed the culls amounted to 23.5 per cent.

In 1895 four varieties were used in the test, and with but one exception the northern-grown seed produced the larger yield and the larger percentage of merchantable potatoes. The second-crop seed had been grown by the station and only the best tubers from the best vines were used.

In the third year's trials seven varieties were grown. A dry and hot spring hastened the maturity of the crop, and although not so marked as in the two preceding years, the results in general were the same.

The average results for the three years show that potatoes from northern-grown seed produced better yields and matured earlier than potatoes grown from second-crop seed. In general second-crop seed was slow and irregular in sprouting and produced vines inferior in vigor and in appearance. No difference was detected in the keeping and cooking qualities of the tubers of the two crops. The average of the average results of each year for the entire series of experiments is given in the following table:

Second-crop seed compared with northern-grown seed—Average of three years.

	Yield of merchantable potatoes per acre.	Yield of culls per acre.	Total yield per acre.	Time from planting to maturity.
	Bushels.	*Bushels.*	*Bushels.*	*Days.*
Northern-grown seed	94.91	11.19	106.10	108.54
Second-crop seed	81.29	16.04	97.84	111.67
Difference	13.62	4.85	8.76	3.13

A comparison of large and small second-crop seed planted as whole or cut tubers resulted in a better total yield and a larger percentage of merchantable crop from the large seed.

Experiments with second-crop potatoes have been carried on at the North Carolina Station for several years and the methods of culture recommended by this station are here briefly summarized. When the tubers of the second crop are to be used for seed the seed tubers are taken from the crop which was planted in the spring and matured early in the summer. The tubers when dug should be perfectly ripe and should then be exposed to the light until they have become greenish in color and spread out on the ground in a single layer well covered with pine straw or leaves. The covering should be kept moist continually and the tubers remain bedded in this way until they begin to sprout. It was found that cutting small pieces from each tuber when bedding them tends to shorten the time required for sprouting and when treated in this way the tubers are planted without any further cutting. Planting seed pieces as practiced in spring did not prove reliable with summer planting at this station, as the stand obtained was frequently unsatisfactory. By planting only those tubers which show signs of sprouting when taken from the bed a good stand can be secured. Culls from the early crop sometimes used as seed are considered less reliable than the well-ripened tubers. The time of planting necessarily varies with the latitude. The middle of August is considered a good time for planting in North Carolina. The method of planting and cultivating recommended is essentially the same as the practice known as the rural trench system. The seed tubers are placed at the bottom of deep furrows, covered lightly, and the soil compacted around them. From time to time as the plants grow the soil is worked to them until the furrows are filled. The subsequent cultivation should be perfectly level. The plants remain green until they are cut down by the frost, and the tubers which are then dug are an immature crop and keep better than if mature. It is advised to keep them in a heap in the open ground, covered with pine straw or earth, or to keep them in a cool dark cellar. The object is to keep them at a temperature of 35° to 40° F. and to admit no light, conditions most favorable for keeping potatoes.

COLD V. WARM WATER FOR PLANTS.

It is the generally accepted opinion of florists and gardeners that watering plants with very cold water is detrimental to growth, but no one has undertaken to state definitely how cold the water may be without producing this result. It is the common opinion, however, that water applied to greenhouse plants should not be much colder than the air immediately about them. In order to ascertain the facts in the case more definitely the Wisconsin Station instituted a series of tests. The plants were grown under glass, except as otherwise noted.

Twelve cuttings of Coleus, as nearly alike in size and vigor as could be obtained, were divided into four lots and planted in sand. They were watered with water at 35°, 50°, 65°, and 86° F. In twelve days all were rooted equally well. They were potted off and the watering continued. There was no noticeable difference in growth and vigor between the various lots until sixty days after the cuttings were taken, when the 86° lot was slightly the highest. This advantage was only temporary, however, for in a few days the 50° and 65° lots slightly exceeded it in height. Ninety days after the cuttings were taken the 35° lot was plainly checked, but the other three were practically equal. This test was repeated with water at 32°, 40°, 70°, and 100°. In this case it was difficult to discover any influence due to the temperature of the water used.

Transplanted tomato plants were divided into four lots and watered with water at 35°, 50°, 65°, and 86°. The 65° lot made the best growth throughout the test, which lasted for thirty days. The 35° lot made the slowest growth, but was in no other respect inferior to the others. This test was repeated with water at 32°, 60°, and 90°. After sixty days the 32° lot was slightly the best. The plants were the tallest, ripened earliest, and the plants and fruit weighed the most. This trial was repeated with plants from seed saved from the fruits of the first crop. Plants from the 32° lot were watered with water at 32°, those from the 60° lot were watered with water at 70°, and those from the 90° with water at 100°.

"In this case the 100° lot yielded the largest amount of fruit and the 32° lot was next in order, while the 70° lot yielded the least; but the difference is so slight that the results may be considered duplicates."

Seed was again saved from this crop, planted, and different lots watered with water at 32°, 40°, 70°, and 100°. Two months from the date of sowing there was no difference between the lots that could be ascribed to the different temperatures of the waters used. "In this case the 32° lot yielded more than the 70° lot, but less than the 100° lot."

A thousand seeds of forcing radish were sown in each of three plats and were watered with water at 32°, 45°, and 70°, respectively. The 32° lot was considerably slower in germinating than the others. In this test the yield of radishes was smallest in average weight in the 32° and largest in the 70° lot, the difference being, however, only 10 to 13 per cent. In a second test, however, there was a noticeable difference. Water at 32° gave decidedly the best results, while 100° gave the poorest.

Beans watered with water at 32°, 40°, 70°, and 100° were equally vigorous. Water at 32° and 40° gave the best results. Lettuce watered with water at 32° yielded slightly more than other lots.

In addition to the above, two trials were made under outdoor conditions. Eighteen half-barrel tubes were sunk in the ground until the tops were level with the surface and filled with soil. All were suitably drained. Nine were watered with ice water; the other nine with hydrant water, which averaged about 75° in temperature. The warm water produced better results than the cold and the difference was much more pronounced in the summer. In the earlier part of the season both lots were equally healthy and vigorous; but later, when the weather had become cooler and the period of most vigorous growth had passed, the plants watered with ice water appeared unhealthy.

Radishes and beans were planted in three plats in the open ground; one plat was watered with ice water, one with hydrant water, and one not watered at all. Those watered with ice water yielded the most and those not watered at all the least, although the rainfall during the season was regarded as nearly or quite sufficient for the development of crops well cared for. The beans showed no difference in yield that could be attributed to the temperature of the water. The yield from the unirrigated plat was in this case also much smaller than either of the others.

In a number of these tests a record was made of the temperature of the soil before watering and at intervals for several hours afterwards. The application of ice water of course immediately lowered the temperature of the soil several degrees. It was found that with plants in pots the original temperature generally was not regained for several hours. The application of water of 40° or above, etc., was found to have no effect of importance, the original temperature being soon regained after a rise or fall.

From the results of these and numerous other trials not here noted the conclusion appears fully warrantable that the growth of ordinary field and garden crops is not affected by the temperature of any water ordinarily available for irrigation purposes.

The temperature of the soil about the roots of the plants so quickly regains its original temperature that no check to growth is likely to result.

It is concluded from the results of the out-door work that no harm can result from using for irrigation purposes water from the coldest springs or wells, for * * * the temperature of the water from these sources will not be less than 40° in any case when taken from the well or spring, and by the means ordinarily employed in irrigation would be raised many degrees above this point before reaching the roots of the plants.

It is concluded from the results of the greenhouse work that for vegetable and flowering plants commonly grown under glass, well or spring water may be freely used at any time of the year without warming.

SOILS AND FERTILIZERS FOR FORCING HEAD LETTUCE.

Within the last few years the forcing of head lettuce has sprung into considerable prominence as an industry. Growers have been generally agreed that the soil mixture was a considerable element in success, but as to what the exact amount and character of the ingredients in this mixture were there was not a little confusion of ideas. In order to obtain more definite information on this subject, the New York State Station undertook a series of tests to ascertain definitely the influence of the texture of the soil on head lettuce. This was the only variety used, and the results obtained very probably do not apply to loose varieties. In all of the tests each soil contained a superabundance of nitrogen, phosphoric acid, and potash, so that for the purposes of this experiment all of the soils might be considered as equal in fertility, and any difference in yield might be attributed to soil texture.

Mixtures of well-rotted clay loam sod and stable manure with various amounts of sand were tried. There was little difference in the yield, but on the mixtures containing 42 per cent of sand the lettuce was a trifle the earliest. On a mixture of five-sixths sand and one-sixth stable manure by weight, the heads were larger, but loose and of poor texture. When the proportion of stable manure was increased to one-third, the lettuce was small, late, and injured by tip burn. Sandy loam with applications of chemical fertilizers alone gave slightly heavier lettuce than clay loam similarly treated, but when it was mixed with one-half its weight of stable manure the clay loam gave much superior lettuce, earliest in maturity and largest in yield of any soil mixture tried. It seems, then, that the soil mixture best adapted for forcing head lettuce is of rather compact texture and contains a good portion of fine sand, clay, and silt, moderately lightened with fairly well-rotted horse manure.

A fertilizer experiment was also made to test the relative merits of stable manure with and without phosphoric acid and sulphate of potash, and to ascertain the effect of increasing amounts of nitrate of soda. It was found that after a soil has received a heavy application of stable manure any further addition of chemical fertilizers is only thrown away. Chemical fertilizers gave best results on sandy soils, fairly well-rotted stable manure on clay soils. Evidently the reason for this difference lies in the texture of the mixtures.

THE DATE PALM IN THE UNITED STATES.

The date palm is a native of the arid regions of northern Africa and southwestern Asia. It was early introduced into America by the Spanish. The history and present status of the date palm in the United States has been made a subject of study by the Arizona Station. The following statements are taken mainly from a bulletin of that station. The palm followed the progress of Catholic missions from St. Augustine to Mexico, New Mexico, Arizona, and California, where it is now grown in the open ground as an ornament as far north as San Francisco. The tree will, however, produce fruit only over a much more limited area. It is not yet grown on a commercial scale anywhere within the United States, though occasional seedlings are found in the desert regions of southern New Mexico, Arizona, and southeastern California, which produce fruit of excellent quality.

The greatest impulse was given to date growing in this country by the importation by the Division of Pomology of this Department of rooted suckers supposed to have been taken from female trees known to produce fruit of excellent quality. These were distributed and planted in Las Cruces, N. Mex.; Phœnix and Yuma, Ariz.; Indio, Pomona, Tulare, and National City, Cal. Of the trees thus planted it appears that 39 are now living, of which 15 have blossomed, 7 of them being pistillate or fruit-bearing plants. It may be two or three years before their true fruit qualities can be ascertained.

The regions in which the date palm thrives are characterized by deficiency of rain and wide variations of temperature. The summer heat is intense, reaching 115° or more, though in winter the thermometer may fall as low as 16° below freezing. These climatic conditions are practically identical with those that obtain in the more southerly portions of the great Colorado desert. So great is the similarity in fact that, so far as climate is concerned, we may reasonably expect the date palm to fruit satisfactorily in the arid regions of our Southwest. Although the date palm requires exceptionally intense heat in summer, it will withstand in winter a temperature that would be fatal to the fig or orange.

Probably the soil best adapted to the date palm is one containing a small percentage of clay, fairly free from humus, and charged with alkali. Irrigation and heat are the all-important considerations. Water is indispensable. The roots should be moist at all times. "The date must have its head in the fire and its roots in the water" is an old Arabian proverb. The water should be applied frequently throughout the year, the most in the spring before blooming and in the fall prior to ripening of the fruit. Care should be taken not to irrigate too much at the time of blooming and just after, as this is liable to interfere with successful fruit setting. The water may advantageously be quite warm, from 75° to 95°, and contain considerable alkali. In midsummer irrigation should be in the late afternoon or evening to avoid scalding.

Palms may be planted along streams or flooded basins. All desert regions are characterized by occasional depressions where the water comes nearly or quite to the surface. During the rainy season these are filled with water and sometimes do not become entirely dry before another rainy season. The date palm thrives in such spots when once established, although its trunk may be partially submerged for some time. Where irrigation is practiced, however, water should not be allowed to rise above the surface of the soil for any considerable length of time, and later to be allowed to dry away, as baking of the soil under these conditions may result in serious injury to the tree. From a study of the soil and climatic conditions in northern Africa, where the date palm flourishes, it seems probable that dates may be grown in the region adjacent to the Salton basin west of Yuma.

The date may be propagated from seeds or suckers. The former method is not much used except in originating new varieties, because, like many other fruits, the date does not come true to seed. The fruit is generally later and poorer, and the excessive number of males that spring up can not be distinguished and destroyed until the tree blossoms, hence propagation by suckers is resorted to, although the date is difficult to transplant with uniform success. Frequently as many as 50 per cent of the transplanted dates die after they have received the best of care, and if neglected hardly any will survive. The Arizona Station gives directions for transplanting as follows:

> Suckers may be removed at any time during the spring or early summer, or even in the winter if proper care be given them after removal. If they are to be planted in the open ground, it is advisable to remove them during the spring or early summer, April probably being the best month. In winter, when the plants are at a standstill, the suckers may be removed with comparatively small loss, if the bulbs be not less than 4 inches in diameter and have a few roots. It is necessary, when suckers are

removed at this season, to set them in rather small pots, so that the earth, which should be given a daily soaking, may have a chance to get warm quickly. The pots should be kept in a greenhouse, or, better yet, embedded in a hotbed of manure, covered with the customary frame and glass. In all cases the leaves should be cut back to 6 to 12 inches in length. * * *

If proper attention can be given it is best to plant the suckers where they are to remain, as a second chance for loss occurs when they are planted in a nursery and later moved to the position that they are finally to occupy.

A two-inch chisel well sharpened, and an appropriate mallet, are the important tools to use in removing suckers. The leaf stalks should be cut away, exposing the bulb of the sucker, care being taken not to injure the bulb in removing. One should cut in rather deeply at either side, not being afraid of injuring the old plant, cutting out a V-shaped portion extending from the base of the bulb downward for a foot or more and being careful to secure in uninjured condition all the attached roots. If the position of the sucker be not too high above the ground, the V-shaped portion should be continued downward into the soil, that all established roots be obtained. The Pomona substation in California has the best success in removing suckers by banking earth about the stem of the plant so as to cover the bulbs a number of weeks prior to removing them. A good system of roots is established by this method of procedure.

The male and female flowers of the palm are borne on separate plants. In the male plant the flowers are crowded closely together on a large branched panicle and have an odor like musty flour. If the panicle is shaken when the flowers are well opened quantities of pollen will escape, filling the air as if with dust. The flowers in the female panicle are much farther apart; the segments are smaller and less spreading. The center of the flower is well filled by three pistils, two of which soon become abortive.

It is evident, then, that male and female trees should be planted near each other. It is quite common to set one male plant in the center of an irregular circle of six or eight females. If the trees are planted in a row along a roadside the male trees should be planted to the windward. The wind may be depended upon as a rule to effect pollination if the staminate is not more than 6 or 7 rods from the pistillate flowers. At greater distances pollination may be effected, though with doubtful certainty of completeness, by both wind and bees.

The palm is peculiar in that the pollen retains its fertility for a long time. It may be transported to great distances and artificially applied to the female blossom with success. Pollen should not be dusted on the flower too profusely, as overpollination is said to weaken the developing dates and cause them to drop from the tree. When artificial pollination is necessary the male blossom is cut from the tree as soon as the cracking of the spathe shows that it is about to open. The panicle may then be cut into pieces and a piece tied near the opening of each female panicle.

The date palm, whether male or female, varies greatly as to time of blooming. It always blooms late, however, thus escaping injury from late spring frosts. In Arizona the blossoming period begins about April 15 and continues six weeks or more. In planting male trees suckers should be selected from those that blossom earliest and most profusely and continue in bloom from three to five weeks.

The varieties of dates are almost innumerable. They vary greatly in size, color, sweetness, delicacy of flavor, and length of time required to mature. The dates of commerce are usually light colored, these being of firmer texture, and are hence preferable for shipping purposes.

The average yield of a tree is eight bunches, each weighing about 17½ pounds, though they may weigh as much as 44 pounds. In Arizona seedling trees seven years of age have produced upwards of 200 pounds in a single season. Young trees blossoming the first or second time should not be allowed to bear more than four or five bunches.

Among the various enemies of the date, birds and bees do much injury by feeding on the ripe fruit. Cheese cloth sacks loosely inclosing the bunches on the tree afford the best protection. The expense should not exceed 10 cents per tree. Grasshoppers do much damage by feeding on the foliage. The most serious pest that the date has in this country is a scale insect that was imported on palms several years ago. The insect is small, but conspicuous against the dark green leaves, both sides of which are infested. The Arizona Station has not yet discovered any means of eradicating the pest. Applications of whale-oil soap washes and fumigation with hydrocyanic acid gas have been only partially successful.

RECENT STUDIES ON THE CODLING MOTH.

It is doubtful if there is any more serious pest of fruit culture in the United States than the codling moth. It has been estimated that from one-fourth to one-half of the annual apple crop is destroyed by this pest, or more than by all other insects combined. The codling moth, indeed, is so destructive that the New Mexico Station has discussed the advisability of destroying a year's fruit crop in that State with the idea of exterminating the insect. Its principal food is apples, though it commonly attacks pears, often feeds upon wild haws and quinces, and sometimes works on such stone fruits as plums, peaches, and cherries.

Frequent failure to obtain good results in treating the codling moth according to the long-accepted rules has led a few stations to thoroughly investigate its life history. Recent investigations of the Cornell and Nebraska Stations on this subject are of special interest. The results obtained are much at variance with statements commonly found in entomological and horticultural writings.

The Nebraska Station states as a result of its investigations that—

> The commonly accepted plan of fighting the codling moth has been to spray the trees with arsenites, either Paris green or London purple, as soon as the blossoms have fallen, and repeat the operation once or twice thereafter at intervals of ten days or two weeks. The efficacy of this treatment, in many cases, has been proved beyond a doubt, yet its inefficacy has been equally well proved in other cases. The assumption has been that the moth begins its work at blossoming time, and that by spraying immediately afterwards we may catch the young larvæ at the time they begin to work. * * * But another factor enters into the problem. When the

blossoms fall, the calyx cup is wide open, but soon after begins to close. Since the young larvæ so often begin their work within this cup, it is important that we have a dose of poison there prepared for them. It can only be put there while the cup is still open. Therefore, to do this we must spray soon after the blossoms fall, as directed. But the efficacy of this spraying plainly depends upon getting the poison in this position, having the cup close over it, and hold it there until the larva comes. Therefore, the nearer to the time at which the cup closes that the spraying can be done, and still get the poison inside, the better, for the less danger there is of its being washed away.

In discussing remedies for the codling moth, the Cornell Station bulletin makes the following statement:

> No panacea for the codling moth has yet been found, but by thorough work by a Paris green spray we can often save at least 75 per cent of the apples that would otherwise be ruined by the worms. Where more than two broods of the insect occur during the season, as in Kansas, Nebraska, Oregon, New Mexico, and neighboring localities in the West, and in the South, the poison spray is not so effective, for although 75 per cent of the first brood of worms may be killed with the spray, the few worms left will form a sufficient nucleus for a large and very destructive second or third brood. In these localities the best that can be advised at present is to supplement the poison spray with the old banding system.

The Nebraska Station suggests the following treatment for the codling moth under the conditions prevailing in Nebraska:

(1) Spray with Paris green, as generally recommended, about one week after the blossoms fall, or in time to get the calyx cups well filled with the poison, so that they may close over and hold it there.

(2) Spray again with Paris green and Bordeaux mixture combined, or with kerosene emulsion, about June 1, or, better still, observe carefully and apply this when the eggs are being laid in abundance on the leaves, which at Lincoln occurs at about this date. Laboratory experiments indicate that kerosene emulsion will be more effective than Paris green at this time.

(3) Scrape the bark and place paper bands around the tree about the last of June, when the larvæ are beginning to leave the apple to pupate. Examine these two or three times, a week apart, and destroy the insects found beneath them.

(4) If these methods are not wholly effective, owing to the proximity of neglected orchards or from an unusual abundance of moths, later spraying, with either Paris green and Bordeaux mixture or kerosene emulsion, may do some good, but apparently can not be expected to be wholly effective. Late spraying with arsenites is much more likely to injure the foliage than earlier applications, and if the other methods are thoroughly followed it will probably be unnecessary.

(5) If larvæ are still found in the apples in any considerable numbers toward the end of the season, place paper bands about the tree about September 1 or a little earlier. Leave them there until the fruit is gathered from the orchard, then remove and destroy the larvæ hibernating beneath them.

(6) Screens placed over the windows and doors of the cellar or rooms where apples have been stored will prevent those larvæ which are taken in with the apples from escaping as moths in the spring.

JERUSALEM ARTICHOKES FOR PIGS.

Much has been written on the subject of the food value[1] of artichokes, but very few careful experiments have been made to determine just what proportion of rations for farm animals can be profitably made up of these tubers. To throw light on this point, the Oregon Station fed six thrifty Berkshire pigs—which had been running on wheat stubble and which weighed from 117 to 215 pounds at the beginning of the experiment—from October 22 to December 11 on artichokes, supplemented by a small ration of equal parts of chopped wheat and oats.

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[1] U. S. Dept. Agr., Farmers' Bul. 73 (Expt. Sta. Work—IV, p. 10).

> An effort was made at the outset to compel the pigs to subsist on a diet of artichokes alone; but in the absence of grain there was very little gain, and the pigs were not contented. They were vigorous in their demands for something more substantial.
>
> The artichokes were grown near the pens, so that the pigs could have access to them whenever they desired. The tubers were left in the ground for the pigs to root out as they were needed.
>
> A portion of the plat was measured and the artichokes dug to determine the yield, which was found to be 740 bushels per acre.

During the experiment the six pigs consumed the artichokes grown on one-eighth acre and made a total gain in live weight of 244 pounds, or an average daily gain per pig of 0.81 pound. The pigs consumed during the period 756 pounds of grain, or at the rate of 3.1 pounds of grain for each pound of gain in live weight. In other experiments it has been found that it requires about 5 pounds mixed grain for each pound of gain in live weight. On this basis the feeding of the artichokes resulted in a saving of nearly 2 pounds of grain for each pound of gain in live weight. The pigs were healthy and vigorous throughout the experiment.

The artichokes used in this experiment "were planted the last of April, on ground plowed deeply and prepared as we would prepare ground for potatoes. The tubers were planted in furrows, which were 3 feet apart. The seed was dropped 18 inches apart in the row and covered with a hoe. The plants were cultivated a few times, but after the tops were 2 feet high no further cultivation was necessary. The tops grew 7 feet high before the end of the season." The pigs left only a few tubers in the ground.

SUPPLEMENTS TO SKIM MILK IN FATTENING CALVES.

The Iowa Station has conducted experiments extending over a number of years to learn what feeding stuffs may be profitably combined with skim milk for calves. In two of the tests linseed meal, ground oats, and a mixture of corn meal and flaxseed were compared as supplements to separator skim milk. In the last test reported corn meal was also included. For this test (which covered 74 days) twelve calves were divided into four lots of three each. During the test each lot consumed about 3,760 pounds of separator skim milk and 1,480 pounds of hay. In addition, lot 1 was fed 429 pounds of linseed meal; lot 2, 605 pounds of oatmeal; lot 3, 59 pounds of flaxseed and 538 pounds of corn meal, and lot 4, 601 pounds of corn meal. The lots were kept in well-ventilated sheds with yards connecting. Salt and water were always accessible. The foods consumed, gains made, and cost per pound of gain in the last experiment are shown in the following table:

Summary of results of calf feeding.

	Nutritive ratio of ration.	Total gain.	Average daily gain per head.	Dry matter eaten per pound of gain.	Cost of feed per pound of gain.
		Pounds.	*Pounds.*	*Pounds.*	*Cents.*
Lot 1. Skim milk, hay, with linseed meal	1:3	483	1.63	4.13	2.5
Lot 2. Skim milk, hay, with oatmeal	1:4.1	498	1.68	4.81	2.2
Lot 3. Skim milk, hay, with flaxseed and corn meal	1:4.8	489	1.65	4.32	2.8
Lot 4. Skim milk, hay, with corn meal	1:4.9	509	1.72	4.16	2.0

From these figures it appears that the best and most economical gains were made on corn meal and skim milk. Comparing the results of all the tests made, it is found that "in each of the three experiments conducted by this station linseed meal has given lower and more expensive gains and has been in every way less satisfactory than either oatmeal or corn meal and flaxseed. * * * The results indicate that pure corn meal is superior to pure linseed meal for feeding calves in combination with skim milk."

While the results of these experiments are contrary to prevailing opinion concerning the relative value of these feeds, it is not unnatural or in any way unreasonable that the carbonaceous grains should be more suitable for feeding with skim milk than a highly nitrogenous product like linseed meal.

The conclusion seems warranted that a nitrogenous feed, such as oil meal, is neither necessary nor most profitable to supplement a separator-milk ration for young calves. All of these rations, even when corn and flaxseed were used, were narrower than whole milk, and it is evident that the element lacking in separator milk is not albuminoids, but fat or its equivalent—carbohydrates—in some form palatable and digestible to calves.

In recent experiments made in Holland the effect of increasing the fat in skim milk for calves or of adding starch was tested. Sufficient whole milk was added to skim milk to make the desired amount of fat.

When starch was fed it was cooked to a paste in the skim milk. About 94 per cent of the starch was digested, the coefficient of digestibility being as high as in the case of the adult animal. The addition of starch to the ration diminished the digestibility of protein somewhat. It was, however, on the whole satisfactory, although the author believes that fat is preferable.

A prominent French investigator has recently published the results of a number of years' experience in feeding starch and skim milk to calves, and regards this combination of foods as very satisfactory. He states that a calf weighing on an average 70 pounds at birth should gain about 2 pounds in weight a day, about 6 quarts of milk being required for this by a calf of the above weight. When the calf is eight days old, starch in the proportion of 1.7 ounces to a quart of milk may be substituted for whole milk. No bad results follow the change in feed and the gains made are satisfactory. The starch should be cooked to a smooth paste with half the milk used, then mixed with the remainder and fed warm. The value of this method of feeding from an economical standpoint is discussed at considerable length.

These experiments all indicate that what might be expected on theoretical grounds is found to be the case in practice. It is known that the body requires protein for its growth and maintenance, and in addition fat and carbohydrates for supplying the necessary energy. Whole milk is the normal food of the calf; it contains a sufficient amount of protein. If the fat is removed, the skim milk supplies the same amount of protein as before, but something must be added as a source of energy. It is known that within limits fat and carbohydrates are interchangeable for this purpose. In the experiments cited above carbohydrates (either in form of starch or cereal grains) were successfully combined with skim milk and in this way the animal was supplied with an abundance of protein and energy and made satisfactory gains. When it is possible to supply protein in a by-product such as skim milk, and the supplementary material in an inexpensive form, the profitable feeding of calves is assured.

PASTEURIZATION OF MILK FOR BUTTER MAKING.

The adoption of pure cultures for starters in ripening cream has led to the quite general use in Denmark of pasteurized milk or cream for butter making. This pasteurization deprives the cream or milk of a large part of the bacteria which it always contains so that the bacteria of the pure culture predominate from the first and largely crowd out those in the cream. In this way the effects of the pure culture are more marked and are not partially masked by the growth of other kinds of bacteria. The use of pure cultures in unpasteurized cream has been likened to the selecting of clover seed with great care so as to avoid all foul seed, and then planting it on soil that has not been previously prepared in any way, in which case it could hardly be expected that the clover would come up clean and remain free from weeds. Similarly, the dairyman, who in using pure cultures is simply carrying on bacterial farming, can hardly expect to reap the full advantage of the pure cultures without first destroying the growing bacteria that exist in the milk and cream.

Although the use of pure cultures has become quite extensive, the practice of pasteurizing, which has practically displaced the old systems in Denmark, has found little if any application in commercial creameries in this country. An extended test of the method, recently reported by the Wisconsin Experiment Station, throws much light upon its practicability and advantages, and the class of creameries which may be expected to benefit by it. Experiments on a commercial scale were made at the creamery of the Wisconsin Dairy School, extending from February to August, thus covering winter, spring, and summer conditions. In these experiments a part of the milk was creamed with a separator in the ordinary way, and another part was pasteurized before creaming by running it through a continuous pasteurizing apparatus which heated it to about 155° F. This pasteurization killed about 94 per cent of the living germs in the milk. The pasteurized and unpasteurized cream was made into butter by a uniform method, using a pure culture starter for ripening the cream, and the product was scored by an expert in Chicago when fresh (from one to two weeks old) and several weeks later, after it had been stored in a butter cellar. The average flavor score (on the basis of 45 as perfect flavor) of 102 churnings of fresh unsterilized butter was 40.69, and of 75 of pasteurized butter was 40.63, practically the same. A slightly larger proportion of the unpasteurized than the pasteurized butter scored 42 points or more. In regard to the flavor the authors of the bulletin say:

> The difference in the fresh scores is so slight that it is impossible from these scores to conclude that one system produces higher flavor than the other. The scorer, however, claimed to be able to detect the pasteurized butter by its "sweet," "curdy," "flat" taste, but did not materially reduce his score on this account. This conclusion is of material consequence, as it is usually claimed that as high a flavor can not be secured in pasteurized butter as in that made in the ordinary way.
>
> Dividing the work into monthly periods (February–August), it can not be said that pasteurizing affects the quality of the butter more at one period than another.

The grain or body of the butter from pasteurized milk was scored considerably lower than that made from unpasteurized milk. In other words, the pasteurizing process appears to injure the grain or body of the butter, according to American standards, although it is suggested that there might not have been this difference if the butter had been scored in markets where pasteurized butter was common.

The pasteurized butter kept better than that from unpasteurized milk. On the average, thirty-nine packages of unpasteurized butter deteriorated 1.2 points in flavor by keeping in a butter cellar for two to four weeks, while thirty samples of the pasteurized butter lost only 0.85 of a point under the same treatment. On this point the butter expert in Chicago says: "Usually I have not been much in favor of pasteurizing cream, but the test that I have just made of these 8-pound pails that were held in storage shows to me that the pasteurizing appears to help hold the sweetness for two or three weeks probably better than unpasteurized butter."

The yield of butter from pasteurized milk was, on the average, a little less than that from unpasteurized milk. The heat applied in pasteurizing was in no way unfavorable to the separation of cream, but in hot weather the buttermilk from the pasteurized cream contained somewhat more butter fat. This was thought to be due to the fact that the pasteurized cream was not as thoroughly cooled, owing to the higher temperature to which it had been heated, for at other seasons there was not much difference in the amount of fat left in the buttermilk.

As to the uniformity of the product, there was only a slight difference in favor of the pasteurized butter, as both kinds of butter were quite uniform in quality. It should be remembered in this connection that the butter was made in the dairy school creamery, under the direction of experts, and under the most favorable conditions for making a uniform product by the ordinary methods. The normal product of this creamery is very uniform, and quite likely greater differences in the uniformity and in the keeping quality of the pasteurized product would have been apparent in the average creamery.

Considering the extra labor and expense involved in the process, and the present demands of the American market, the station does not recommend its introduction into creameries that already make a good product. It is believed, however, that in creameries where difficulty is experienced in making a thoroughly first-class product of uniform quality it would be a material advantage.

"If the demand for export butter should ever reach any considerable proportions, the employment of this system might be of value, since the present standards demanded by the foreign market are as easily obtainable, or even more so, by the pasteurizing system as any other. Then, again, it should be remembered the methods used in this system have by no means reached their highest state of perfection, and that further study may give us better results."

GASSY AND TAINTED CURDS.

The progress of investigation on the relation of bacteria and other micro-organisms to cheese making has shown in a striking way to how great an extent the production of inferior cheese is due to the failure of the cheese maker to prevent or control the action of undesirable bacteria. A common trouble is the presence of disagreeable taints which develop in the milk and curd during cheese making. These are usually, though not always, accompanied by the formation of gas, which results in a gassy curd. Several of our stations have investigated the cause of these troubles, notably the Wisconsin Station, and a recent investigation at the New York Cornell Station was undertaken to determine the source of the infection.

A cheese factory in which the difficulty occurred received milk from a dairy in which there had been considerable trouble from cows retaining the placenta or afterbirth. This was popularly believed to be the source of the taints in the milk and the gassy curd. An investigation of the milk and curd showed that both the taint and the gas were caused by a species of gas-producing bacteria. In proof of this, cheese was made from sterilized milk, to which a culture of this bacillus was added, with the result that the taint and the gassy curd developed. When the milk of the cows which had suffered from retained placenta was rejected the taint and gassy curd continued to develop, and on examining the milk of each of the cows in the dairy it was found that the bacteria producing the gas and taint were present more or less constantly in the milk of all the animals. An examination of the water used in cleaning the utensils and of the dust and filth of the stable failed to establish these as sources of the bacteria. After the stable was thoroughly cleaned and disinfected the trouble continued. This suggested that the germs got into the milk through the teat rather than from the particles of dust which fell into the milking utensils. It is known that bacteria are able to work their way up into the opening of the teat and there continue their growth, being partly washed out during milking, enough being left to continue the growth. In this way the freshly drawn milk continues to be inoculated with the germs, and under these conditions it is impossible to obtain germ-free milk even when every possible precaution is observed. That this theory regarding the source of the bacteria in this case is correct is strengthened by the results of examinations which were made of the teats and udders of a number of cows slaughtered on account of tuberculosis. The cows were milked before they were slaughtered, and immediately after slaughtering the udders were dissected and bacteria cultures made from the milk found in them and from the tissue. The same organisms were found in the milk and in the milk cistern and udders of the cows, showing that the bacteria remained in the udders after milking, ready to infect the next succeeding milking.

When the source of infection is located in the passage of the teats or the udder, the difficulty of removing it is much greater than when it is due to some external infection; but in the case cited the observation of unusual cleanliness in the stable, and the constant cleaning of the udders and teats was rewarded by the gradual disappearance of the taint. The constant cleaning prevented reinfection, so that when the teats happened to be cleared of the organism they were not again infected with it.

One of the chief lessons from work of this sort is the necessity of cleanliness in the stable and in the care of the cows, and prompt attention to any taint which may appear in the milk. A taint is like a contagious disease. It starts from some point, possibly a single cow, and spreads rapidly or is communicated to the milk of the other cows by mixing the milk. Like contagion, it is much more easily controlled and suppressed in the earlier stages, before it has become widespread; later, not only the cows themselves, but the stable, dairy utensils, clothes of the milker, etc., become charged with the germs causing it and are sources of the infection until they are disinfected.

PURE CULTURES OF BACTERIA FOR CHEESE MAKING.

The use of pure cultures of bacteria for ripening the cream in butter making has become very familiar within the past few years, and has been adopted in creameries to some considerable extent. But the use of pure cultures in cheese making has more of the element of novelty in it. Two or three years ago the Wisconsin Experiment Station made some experiments with a pure culture of the bacteria causing the souring of milk, which is believed to be a potent factor in the ripening of cheese. In the opinion of a disinterested party who scored the cheeses, the use of the pure culture improved not only the flavor of the cheese, but its texture as well. In addition to this, the cheeses made with the pure culture were more uniform in quality than cheeses made at the same time without any starter, there being less variation in flavor and texture of different cheeses made on the same day.

Recently, experiments in Scotland have been reported in which pure cultures were used on a commercial scale. The cultures, like those used at the Wisconsin Station, consisted of a form of lactic-acid bacteria, which subsequent investigation showed to be very prevalent in sour milk, whey, and cheese of fine quality, and very similar to the pure cultures used for butter making. The pure cultures were tested quite extensively at one factory during the summer, and were also tried by thirty-two different cheese makers. More than 100 tons of cheese was made with their use. The qualities of the cheese were good, and there was an absence of "the undesirable fodder taste common to spring cheese." A number of the cheese makers who tested the cultures continued to use them all summer and requested that they be supplied with them the following season. In several cases cheese made with the pure cultures took prizes at exhibitions. One noticeable result from their use was greater uniformity in the product.

Trials of pure cultures in two dairies for the purpose of preventing discoloration of the cheese resulted favorably, "and in a third dairy discoloration ceased as soon as the culture was used."

The author considers that the experiments have shown the use of pure cultures in cheese making to be both successful and practical, and believes that there is every probability that the system may be used with great advantage where there is danger of discoloration, difficulty in getting a firm curd, where a starter of some kind is necessary owing to the conditions for keeping milk being imperfect, where there is trouble from tainted milk or tainted curd, for the production of cheese in spring and autumn, and for securing greater uniformity in quality.

EXPLANATION OF TERMS.

TERMS USED IN DISCUSSING FERTILIZERS.

Complete fertilizer is one which contains the three essential fertilizing constituents, i. e.. nitrogen, phosphoric acid, and potash.

Nitrogen exists in fertilizers in three distinct forms, viz, as organic matter, as ammonia, and as nitrates. It is the most expensive fertilizing ingredient.

Organic nitrogen is nitrogen in combination with other elements either as vegetable or animal matter. The more valuable sources are dried blood, dried meat, tankage, dried fish, and cotton-seed meal.

Ammonia is a compound of nitrogen more readily available to plants than organic nitrogen. The most common form is sulphate of ammonia, or ammonium sulphate. It is one of the first products that results from the decay of vegetable or animal substances.

Nitrates furnish the most readily available forms of nitrogen. The most common are nitrate of soda and nitrate of potash (saltpeter).

Phosphoric acid, one of the essential fertilizing ingredients, is derived from materials called phosphates. It does not exist alone, but in combination, most commonly as phosphate of lime in the form of bones, rock phosphate, and phosphatic slag. Phosphoric acid occurs in fertilizers in three forms—soluble, reverted, and insoluble phosphoric acid.

Potash, as a constituent of fertilizers, exists in a number of forms, but chiefly as chlorid or muriate and as sulphate. All forms are freely soluble in water and are believed to be nearly, if not quite, equally available, but it has been found that the chlorids may injuriously affect the quality of tobacco, potatoes, and certain other crops. The chief sources of potash are the potash salts from Stassfurt, Germany—kainit, sylvinit, muriate of potash, sulphate of soda, and sulphate of potash and magnesia. Wood ashes and cotton-hull ashes are also sources of potash.

TERMS USED IN DISCUSSING FOODS AND FEEDING STUFFS.

Water is contained in all foods and feeding stuffs. The amount varies from 8 to 15 pounds per 100 pounds of such dry materials as hay, straw, or grain to 80 pounds in silage and 90 pounds in some roots.

Dry matter is the portion remaining after removing or excluding the water.

Ash is what is left when the combustible part of a feeding stuff is burned away. It consists chiefly of lime, magnesia, potash, soda, iron, chlorin, and carbonic, sulphuric, and phosphoric acids, and is used largely in making bones. Part of the ash constituents of the food is stored up in the animal's body; the rest is voided in the urine and manure.

Protein (nitrogenous matter) is the name of a group of substances containing nitrogen. Protein furnishes the materials for the lean flesh, blood, skin, muscles, tendons, nerves, hair, horns, wool, casein of milk, albumen of eggs, etc., and is one of the most important constituents of feeding stuffs.

Gluten is the name given to one of the most important of the nitrogenous substances classed together under the general term "protein." "Wheat gum," obtained by carefully chewing wheat, is a familiar example. It is the gluten of flour that gives consistency to dough.

Carbohydrates.—The nitrogen-free extract and fiber are often classed together under the name of carbohydrates. The carbohydrates form the largest part of all vegetable foods. They are either stored up as fat or burned in the body to produce heat and energy. The most common and important carbohydrates are sugar and starch.

Fiber, sometimes called crude cellulose, is the framework of plants, and is, as a rule, the most indigestible constituent of feeding stuffs. The coarse fodders, such as hay and straw, contain a much larger proportion of fiber than the grains, oil cakes, etc.

Nitrogen-free extract includes starch, sugar, gums, and the like, and forms an important part of all feeding stuffs, but especially of most grains.

Fat, or the materials dissolved from a feeding stuff by ether, is a substance of mixed character, and may include, besides real fats, wax, the green coloring matter of plants, etc. The fat of food is either stored up in the body as fat or burned to furnish heat and energy.

MISCELLANEOUS TERMS.

Alkali soils.—Soils found in arid or semiarid regions, which contain an unusual amount of soluble mineral salts (alkali), which effloresce or bloom out in the form of a white powder or crust in dry weather following rains or irrigation. Two distinct classes of alkali are known: White akali, composed largely of sulphate of soda and common salt, which is comparatively harmless; and black alkali, composed largely of carbonate of soda, which is highly corrosive and destructive to vegetation.

Humus is the name applied to the partially decomposed organic (animal and vegetable) matter of the soil. It is the principal source of nitrogen in the soil.

Micro-organism, or **microscopic organism**, is a plant or animal too small to be seen without the aid of a compound microscope.

Bacterium (plural, **Bacteria**) is the name applied in common to a number of different or closely related microscopic organisms, all of which consist of single short cylindrical or elliptical cells or two such cells joined end to end and capable of spontaneous movement. Many kinds of bacteria are harmful and cause diseases and other injurious effects, but many are beneficial. Among the latter are those which give aroma to tobacco and flavor to butter and cheese, and those which enable leguminous plants to use the free nitrogen of the air.

Bacillus (plural, **Bacilli**) is a genus, or kind, of **Bacterium**.

Culture, as here applied to bacteria or other organisms, is the product of their growth under artificial conditions.

Pure culture is a culture containing one kind of organism. Pure cultures of yeast are used in wine making, and pure cultures of bacteria are used in butter and cheese making, and for other purposes, to insure a uniform product.

Sterilized milk or cream, properly speaking, is that in which all the germs have been destroyed (usually by repeated heating to 212° F.—boiling point), but in dairy practice the term is applied to milk or cream which has been heated once to a temperature of about 212° F.

Pasteurized milk or cream is that which has been heated to a temperature (about 155° F.) which does not kill all the bacteria, but only those which are in a vegetating condition and ready to begin their activity at once.

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83. Tobacco Soils. Pp. 23.
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85. Fish as Food. Pp. 30.
86. Thirty Poisonous Plants. Pp. 32.
87. Experiment Station Work—VIII. Pp. 32.
88. Alkali Lands. Pp. 23.
89. Cowpeas. Pp. 16.
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113. The Apple and How to Grow It. Pp. 32.
114. Experiment Station Work—XIV. Pp. 28.
115. Hop Culture in California. Pp. 27.
116. Irrigation in Fruit Growing. Pp. 48.
117. Sheep, Hogs, and Horses in the Northwest. Pp. 28.
118. Grape Growing in the South. Pp. 32.
119. Experiment Station Work—XV. Pp. 31.
120. The Principal Insects Affecting the Tobacco Plant. Pp. 32.
121. Beans, Peas, and other Legumes as Food. Pp. 32.
122. Experiment Station Work—XVI. Pp. 32.
123. Red Clover Seed. Pp. 11.
124. Experiment Station Work—XVII.
125. Protection of Food Products from Injurious Temperature. Pp. 26.

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U. S. DEPARTMENT OF AGRICULTURE.

FARMERS' BULLETIN No. 93.

SUGAR AS FOOD.

BY

MARY HINMAN ABEL.

PREPARED UNDER SUPERVISION OF OFFICE OF EXPERIMENT STATIONS.

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LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Office of Experiment Stations,
Washington, D. C., February 4, 1899.

Sir: I have the honor to transmit herewith an article on sugar as food, prepared by Mrs. Mary Hinman Abel, in accordance with instructions given by the Director of this Office.

In preparing the article Mrs. Abel has made an extended study of the literature of the subject and has had the opportunity of discussing doubtful points with specialists in physiology and hygiene.

The work of the Division of Chemistry of the Department has been drawn upon as well as the results of the nutrition investigations conducted under the direction of this Office.

The relatively small number of definite investigations regarding the food value of sugar which have been found is a matter of some surprise. There are a number of points concerning the actual food value of this staple article of diet which are rather matter of opinion than established fact. This emphasizes the need of experiments along these lines.

It is believed that this article is a useful summary of available information concerning sugar as a food, and its publication as a Farmers' Bulletin is therefore respectfully recommended.

A. C. True,
Director.

Hon. James Wilson,
Secretary of Agriculture.

CONTENTS.

Page.
Extent of the use of sugar 7
Chemical composition of sugar 7
  Characteristics of cane sugar 8
  Characteristics of other kinds of sugar 8
Sources of cane sugar 10
  The sugar cane 10
  The sugar beet 11
  The sugar maple 11
  Quality of sugar from different sources 12
Food value of sugar 13
  Digestion of sugar 14
  Sugar as a food for muscular work 14
  Sugar as a fat former 18
  Sugar as a flavor 18
  Food value of molasses 19
  Nutritive value of sugar cane 20
Practical use of sugar in dietaries of adults 21
  Amount and concentration 21
  Bad effects ascribed to sugar 23
  Effect of exercise on the amount of sugar which may be eaten 23
  Sugar in cooked foods 23
  Confectionery 23
Sugar in the dietaries of children 24
General conclusions 25

SUGAR AS FOOD.

EXTENT OF THE USE OF SUGAR.

The pleasant flavor of sugar, together with what we now know of its nutritive value, will account for its great popularity as a food. It may almost be said that people eat as much sugar as they can get, and the consumption of sugar in different countries is, in general, proportional to their wealth.

The English-speaking people are the largest consumers of sugar. In 1895 England consumed 86 pounds per capita and the United States 64 pounds, although still larger amounts are said to be consumed in sugar-growing districts, largely in the form of the ripe cane. Denmark and Switzerland consumed in the same year 45 pounds per capita, and Germany, France, and Holland about 30 pounds. Near the end of the list are Italy, Greece, and Turkey, with a consumption of less than 7 pounds per capita. The consumption of sugar is everywhere increasing. Seven to eight million tons are used annually in the different countries of the world.

CHEMICAL COMPOSITION OF SUGAR.

By the term sugar as here used, is meant cane sugar, so called because it was first manufactured from the sugar cane, although it is also found in the juice of a number of plants. Besides cane sugar there are a number of other sugars, as grape sugar, fruit sugar, and milk sugar. Considered chemically, all sugars are carbohydrates; that is, bodies composed of the three elements—carbon, hydrogen, and oxygen—the oxygen and hydrogen being in the same proportion as in water, which is made up of two atoms of hydrogen and one of oxygen. The principal carbohydrates which serve as food may be classified as follows: (1) Monosaccharids, including hexoses, such as glucose, or grape sugar, and levulose, or fruit sugar, made up of 6 atoms of carbon, 12 atoms of hydrogen, and 6 atoms of oxygen; (2) disaccharids, such as cane sugar and milk sugar, made up of 12 atoms of carbon, 22 of hydrogen, and 11 of oxygen, and (3) polysaccharids, such as starches, made up of 6 atoms of carbon, 10 of hydrogen, and 5 of oxygen, this combination being repeated an unknown number of times. It will be seen that the second group is twice the first minus the elements of water, and that the third is the same as the first minus water. When by chemical means water is added to the second group, it is separated into two hexoses, and when water is added chemically to group 3, two or more hexoses are formed. This process is called inversion, or hydrolysis, and may be produced in a number of ways. It is spoken of later. It will be seen that each group contains a number of different members; for example, grape sugar and fruit sugar have the same chemical composition. This does not mean that they are identical bodies. Their difference in properties is explained on the ground that although they contain the same kinds of elements with the same number of atoms, the atoms are differently grouped. This must not be confused with the fact that the same sort of sugar may be obtained from widely different sources; thus, grape sugar is found in grapes and other fruits, and cane sugar is found in the juice of the sugar cane, beets, carrots, and other plants.

CHARACTERISTICS OF CANE SUGAR.

In appearance pure cane sugar consists of a mass of white crystals. It dissolves easily in about one-half its weight of cold water and in still less of hot water. It is very sweet to the taste, two and one-half times as sweet as grape sugar.

At 320° F., which is considerably above the boiling point of water (212° F.), sugar melts into a colorless liquid which rapidly takes on an amber hue. If cooled at this point, it hardens into a glassy mass, transparent and brittle, called "barley sugar." If heated still higher, it browns, becoming less sweet and taking on a bitter flavor. This browned sugar is called caramel. Old-fashioned brown sugar owed its color and flavor, in part, at least, to caramel, for, as sugar was formerly made, in the process of evaporation over the open fire some of the sugar was caramelized or half burnt, since in the final stages the mass became so thick that it could not move about freely and exchange heat, and the layer next to the bottom of the kettle was raised far above the boiling point.

CHARACTERISTICS OF OTHER KINDS OF SUGAR.

As already stated, there are other sugars besides cane sugar. The one most frequently met with is dextrose or grape sugar, which is much less sweet than cane sugar and differs from it chemically. It may be seen in yellowish grains in the raisin and is found in small quantities in other fruits. Dextrose chiefly occurs, however, as the result of the change known as inversion, which takes place in cane sugar, starch, etc., when heated in a solution with dilute acids or when treated in some other way to induce hydration—i. e., cause them to unite chemi-ly with water. Cane sugar in this case splits up into a mixture of dextrose and levulose, known as "invert" sugar. The commercial glucose is dextrose made by hydrolizing starch.

Cooks have often observed that more sugar is necessary in sweetening acid fruits if it is heated with them from the first than if it be added when the cooking is completed. This is because some of the cane sugar, acted on by the heat and acid, has been changed to those other bodies which are less sweet. The effect of heat and acids in "inverting" cane sugar has constantly to be kept in view in the manufacture of sugar. By the slow methods formerly in use on the sugar plantations the juice of the cane was already sour when the boiling began, and these acids in the presence of heat inverted much of the cane sugar, and the mischief was further increased because the very presence of glucose or of caramel in a solution of cane sugar renders the crystallization of the sugar very difficult. The confectioner knows that if he wishes to prevent a concentrated solution of sugar from crystallizing, as in making "fondant" or soft filling for bonbons, he has but to add a small proportion of commercial glucose.

The change of cane sugar in solution to dextrose and levulose is brought about to some extent by the action of heat, even when no acid is present. It is also caused by the action of certain ferments, such as invertin, an enzym which occurs in connection with yeast, and by ferments found in the intestinal tract.

Milk sugar is another important sugar. Milk yields from four to five per cent of this form, and it is not found elsewhere. It is said to be the most digestible sugar for infants.

Honey as stored by the honeybee was formerly very highly prized as a food and flavor. This is less the case since cane sugar has become so cheap and plentiful. In addition to very small quantities of cane sugar, honey consists of a mixture of glucose and levulose (about 37 per cent of each). Honey also contains water and a small amount of mineral matter. It owes its flavor to volatile bodies found in the flowers from which it is obtained, and this flavor varies according to the source from which the honey is gathered, that from some flowers having a more agreeable flavor than that from others. Honey has been used from the earliest times, and is generally regarded as wholesome in moderate amounts. Strained honey is very frequently adulterated with commercial glucose sirup and other materials. While there is no reason for assuming that the manufactured glucose, if properly prepared, is more harmful than the glucose found in fruits, it is a cheaper article, and the fraud consists in selling a low-cost article under a false name for a high price.

Glycogen is a carbohydrate having the same chemical composition as starch. It has, however, different chemical properties. Glycogen is found in small amounts in muscular tissue, and more abundantly in the liver, where it may exist, indeed, in considerable quantity. It serves an important function in nutrition, being stored by the animal body as a reserve material.

SOURCES OF CANE SUGAR.

Cane sugar, sucrose, or simply sugar, as it is known to commerce and in the household, exists dissolved in many vegetable juices. It is found in the stems and roots of all the grasses, especially in the sugar cane and sorghum; in fleshy roots, as the beet, carrot, turnip, and sweet potato; in the sap of trees, as the date palm and sugar maple; in almost all sweet fruits, and in the nectar of flowers; but in only a few of these is the proportion of cane sugar large enough to make profitable its separation from the other substances which these juices hold in solution.

The manufacture of sugar as at present known is an art that has developed from crude beginnings. Sugar is a staple article of food, just as is bread or meat, but few people realize that, unlike meat and bread, it has been a staple food for but a few generations. Only, indeed, in the last half century has it been produced in such quantities and at such a price as to bring it within the reach of all classes of people.

THE SUGAR CANE.

The sugar cane is a gigantic jointed grass (*Saccharum officinarum*), native in eastern India and China, numerous varieties of which are now grown in the tropical and subtropical regions of both hemispheres.

Sugar from the sugar cane was probably known in China 2,000 years before it was used in Europe. When merchants began to trade in the Indies it was brought westward with spices and perfumes and other rare and costly merchandise, and it was used for a long time exclusively in the preparation of medicines. An old saying to express the loss of something very essential was "Like an apothecary without sugar." Greek physicians several centuries before the Christian era speak of sugar under the name of "Indian salt." It was called "honey made from reeds," and said to be "like gum, white and brittle." But not until the Middle Ages did Europeans have any clear idea of its origin. It was confounded with manna or was thought to exude from the stem of a plant, where it dried into a kind of gum. When in the fourteenth or fifteenth century the sugar cane from India was cultivated in northern Africa the use of sugar greatly increased, and, as its culture was extended to the newly-discovered Canary Islands and later to the West Indies and Brazil, it became a common article of food among the well-to-do. In 1598 Hentzer, a German traveler, thus describes Queen Elizabeth, then 65 years of age: "Her nose is a little hooked, her lips narrow, and her teeth black, a defect the English seem subject to from their great use of sugar." By many the new food was still regarded with suspicion. It was said to be very heating, to be bad for the lungs, and even to cause apoplexy. Honey was thought to be more wholesome, because more natural than the "products of ed invention."

THE SUGAR BEET.

The sugar consumed in this and other countries up to 1850 was nearly all derived from the sugar cane, but at the present time two-thirds of the sugar crop is from the sugar beet. Between 1863 and 1883 Germany, one of the leading beet sugar producing countries, increased its output 338 per cent. It would once have seemed incredible that the kitchen garden should furnish a rival for the "noble plant" that had made the fortunes of Spanish and English colonists, but the cultivation of the beet has in one generation shifted the center of the sugar industry from the tropic to the temperate zone. This growth has been fostered by strange vicissitudes in the fortunes of nations, as the commercial embargoes and sugar bounties of the Napoleonic wars and by the emancipation of slavery in the British colonies, giving, as it did, a temporary check to the growth of the cane; but the real creators of the new industry were men of scientific training who solved certain botanical and chemical problems. The manufacture of sugar is now a chemical industry as much as is tanning and dyeing.

Marggraf, a chemist of Berlin, first discovered in 1747 that beets, with other fleshy roots, contained crystallizable sugar identical with that of the sugar cane. In 1796 Marggraf's pupil, Achard, erected the first manufactory for beet sugar, and in 1799 he brought the subject before the French Academy. He manufactured beet sugar on his farm in Silesia, and presented loaves of refined beet sugar to Frederick William III, of Prussia, in 1797; but the 2 to 3 per cent of sugar that could be extracted by the methods then in use was too small for commercial success. A new stimulus was given by the sugar bounties of Napoleon in 1806, and methods were rapidly improved, especially in France. Two great difficulties were still to be met; the percentage of sugar present in the beet was small (6 per cent), and it was separated with great difficulty from the many nonsugar constituents, some of them acrid and of very unpleasant taste. Science now came to the rescue, and a beet was gradually developed having a larger percentage of sugar and a smaller percentage of the undesirable impurities. Barber says that in 1836 18 tons of beet root was necessary to produce 1 ton of sugar; in 1850 this quantity was reduced to 13.8; in 1860, to 12.7 tons, and in 1889, to 9.25 tons. From 6 per cent of sugar as found by Marggraf the sugar beet of good quality now contains 15 per cent and more, 12 per cent being considered necessary for profitable manufacture.

THE SUGAR MAPLE.

The sugar maple of North America is also a source of sucrose, the trees being tapped in the early spring to obtain the sap as it flows upward. The sap was formerly simply boiled down in open kettles and used as molasses, or the evaporation was continued until the sugar crystallized and the brown maple sugar was obtained. Five gallons of sap yielded about 1 pound of sugar. Improvements in the process have been devised. The sugar is now made more easily and quickly by the use of evaporating pans, etc. Maple sugar or sirup commands a higher price than white sugar from the beet or cane and is now used as a luxury because of its agreeable flavor, although it is still an article of regular diet in Lower Canada, as it was formerly among the farmers of New England and other regions. According to figures obtained from the United States Treasury Department, 6,900,000 pounds of maple sugar were produced in this country in 1894. These figures are based on the bounty paid to the sugar makers. A claim for bounty could not be made on less than 500 pounds. The amount of maple sugar produced, including that on which no bounty was paid, was over 7,500,000 pounds. Statistics later than 1894 were not available.

In this connection it is of interest to quote a paragraph from a book written by the eminent Robert Boyle and printed at Oxford in 1663:

> There is in some parts of New England a kind of tree * * * whose juice that weeps out of its incisions, if it be permitted slowly to exhale away the superfluous moisture, doth congeal into a sweet and saccharine substance, and the like was confirmed to me by the agent of the great and populous colony of Massachusetts.

The cane and the sugar beet are, however, the only important sources of sugar (sucrose). Of the world's crop of 7,707,500 tons in 1896, 2,747,500 tons were from cane and 4,900,000 tons from the beet.

QUALITY OF SUGAR FROM DIFFERENT SOURCES.

The methods used in the manufacture of sugar are all to the end of separating the sugar from the other constituents of the juice. In a word, the juice containing the sugar is expressed or extracted from the cane, beet, etc., treated to remove the nonsaccharin substances which prevent crystallization, evaporated in a vacuum apparatus, the sugar crystallized, and the crystals separated from the molasses in centrifugals. The sugar thus obtained, known as raw sugar, contains impurities from which it is separated by the processes of refining. The methods of manufacturing sugar have been described in a previous bulletin of this series.[1]

The average composition of raw sugar from a number of different sources is as follows:

Average composition of raw sugar.

Source from which obtained.	Water.	Cane sugar.	Other organic substances.	Ash.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
Sugar cane	2.16	93.33	4.24	1.27
Sugar beet	2.90	92.90	2.59	2.56
Sorghum	1.71	93.05	4.55	.68
Maize	2.50	88.42	7.62	1.47
Palm	1.86	87.97	9.65	.50
Maple		82.80		

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[1] U. S. Dept. Agr., Farmers' Bul. 52. The Division of Chemistry of this Department has issued a number of bulletins concerning the manufacture of sugar from sugar cane, sorghum, and sugar beets.

Raw cane sugar from these various sources takes on in each case the character of the impurities from which it has not yet been freed. Thus, the raw product of the sugar cane and sugar maple is pleasant in flavor, that of the beet acrid and disagreeable; the raw palm sugar or jaggary is of low sweetening power because of the large amount of invert sugar (dextrose and levulose, see p. 7) that has resulted from fermentation and too high a degree of heat used in evaporating it, while raw sorghum and maize sugar has each the characteristic taste of its sirup. From all these raw sugars the pure cane sugar or saccharose, as known to the chemist, can be crystallized out, and in every case the sugar is identical in chemical composition, appearance, and properties. By no chemical test can pure crystallized saccharose or "cane sugar" from these different sources be distinguished. There is a popular impression to the contrary, however, and it is often asserted that beet sugar has less sweetening power, or that fruits preserved with it do not keep as well, but this can only be true of specimens that have been imperfectly purified.

Methods of refining raw sugar have been so improved in the last few years that it may be truly said that few food substances are so nearly pure chemically as the best granulated or lump sugar. Blythe says:

> Loaf sugar is, as a rule, chemically pure. It is probably, indeed, the purest of all substances in commerce, and a large quantity may be burnt up without obtaining a trace of nitrogen and without leaving any residue. The only sugars that may be impure are the raw sugars.

Out of 500 samples of sugar examined by the Division of Chemistry of this Department[1] not one was found to be adulterated. The present low price of cane sugar protects it from such attempts.

FOOD VALUE OF SUGAR.

Our chief practical interest lies in the use made of sugar in the animal organism, or its food value. Within certain limits we can look upon sugar as the equivalent of starch that has been digested and made ready for absorption. A mealy boiled potato or a lump of laundry starch is in fact very near akin to a lump of sugar; and the potato, like all forms of starchy food, must be turned into a kind of sugar by the digestive juices before it can be absorbed as food by the system.

The statement is commonly made that the food eaten by the average adult is at least one-half of vegetable origin, and analyses show that the nutrients of vegetable foods are very largely starch. The average of 87 dietary studies made in the United States shows 45 per cent animal food and 55 per cent vegetable food. Starch furnishes a considerable part of the heat and muscular power of the body. Therefore starch or any food that will serve the same purpose is of great importance.

To understand this better we must follow the course of starch digestion. When starchy food, as a morsel of boiled potato, is taken into the mouth, it is at once acted on by a ferment contained in the saliva, and this action is continued by a ferment contained in the intestines. It is broken up into simpler chemical compounds and it finally reaches the blood and muscles as dextrose, a form of sugar which can be burned to yield heat and muscular energy. When an excess of carbohydrates (sugar or starch) is consumed, the dextrose in the digestive tract is converted in the liver to glycogen and stored until required, being then, it is believed, reconverted into dextrose. More complex changes may take place which convert carbohydrates consumed in excess into fat which is also stored as a reserve material.

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[1] U. S. Dept. Agr., Division of Chemistry Bul. 13, pt. 6.

DIGESTION OF SUGAR.

If a solution of cane sugar be injected into the blood, it is passed out by the kidneys unchanged, showing that it is not fitted for assimilation. The change needed, however, is slight compared with that required for the digestion of starch; it is "inverted" or changed into the simpler sugars as already described, and this change is brought about in the digestive tract by the agency of enzyms or ferments of whose nature we know little. When thus changed into the simpler sugars its function in the body is similar to that of starch after it has reached the analogous stage in digestion.

SUGAR AS A FOOD FOR MUSCULAR WORK.

Food must supply enough protein or nitrogenous material for the formation and repair of tissue and for certain other uses in the body and in addition sufficient nitrogen-free material to make up the required amount of energy necessary for heat and muscular work. Nitrogen-free material consists of fat and carbohydrates. In the ordinary diet the relative amount of fat and carbohydrates is usually regulated by personal preference. Fat will furnish two and one-fourth times as much energy as carbohydrates. Taking account of this fact it is immaterial on theoretical grounds which of these nutrients supplies the necessary energy, although this is, however, not the case from the standpoint of hygiene.

The main function of sugar as found in the blood, whether resulting from the digestion of sugar or of starch, is believed to be the production of heat and energy. The proof has been amply furnished by experiment. By ingenious devices the blood going to and from a muscle of a living animal may be analyzed and it is thus shown that more blood traverses an active or working muscle and more sugar disappears from it than is the case with a muscle at rest.

The question naturally arises, How does the sugar of our food differ from starch as a source of muscle power? The fact that we have in this manufactured article practically the same substance as that which results from the digestion of starch as found in vegetable foods at once suggests its substitution for starch to the advantage of the system, since it does not burden the digestive tract and less force is required for its digestion. To decide this question much careful laboratory work has been carried on since 1893, when Mosso, an Italian investigator, first examined the influence of cane sugar in lessening fatigue. This he did by the use of the ergograph, an instrument devised by him for testing the work done by certain muscles of the hand. He found, as a result, that sugar in the food, in not too great quantities and not too concentrated, lessens or delays fatigue and increases working power.

Prof. Vaughan Harley continued these experiments in Mosso's laboratory, using much larger quantities of sugar, with the result that the amount of muscle work was greatly increased by it. He compared the work he could do in twenty-four hours fasting with what he could do when taking 500 grams (17½ ounces) of sugar dissolved in pure water, and found that on the sugar day he could do 61 to 76 per cent more work, or almost as much as on a full ordinary diet. When 9 ounces of sugar was added to the ordinary diet or to a meager diet, the gain in muscle power was also considerable. The effect, although felt one-half hour after eating, was at its height in two hours. Very interesting also was the effect of sugar in delaying the natural coming on of fatigue which has been found to occur between 5 and 7 p. m. If three to four ounces of sugar were taken a short time before this hour the ordinary fatigue did not appear and work went on as usual.

The following year Dr. Langemeyer, working under the direction of Professor Stockvis, of Amsterdam, repeated these experiments with great care on several different persons, the work extending over a period of eight weeks. The ergograph, which recorded the amount of work done, was concealed from the person using it in order that he might not unconsciously influence the result, a caution not observed in Mosso's laboratory. Dr. Langemeyer obtained only negative results as to the effect of sugar on muscle work; an increase of muscle power occurred as often when no sugar was taken, or after a short rest, or after taking a drink of water.

At about the same time the Prussian war office authorizod a test of Professor Mosso's results; the work was undertaken by Dr. Schumberg in Professor Zuntz's laboratory in Berlin, and the result was published February, 1898. The ergograph was used in this case also and the subject of the experiment, who was entirely ignorant of its nature, was given daily in addition to his other food 200 grams of a sweet fluid which on certain days was a solution of 30 grams of sugar and on other days was water made equally sweet with dulcin, a sweet-tasting chemical having no food value. By this precaution it was hoped to eliminate the influence which may have affected the results of Mosso and his pupils, even against their will. The results seemed at first to corroborate those of the Amsterdam laboratory and thus to deny any immediate effect of sugar in increasing muscle power. When, however, the subject of the experiment performed some very exhausting work, as with a lathe, before beginning on the ergograph, the difference in the effect of dulcin and sugar became very apparent, the sugar restoring to some extent the efficiency of the tired muscle, while dulcin did not. The explanation given was that a little more or less sugar in the blood was of no consequence in ordinary exertion, but it was otherwise when the sugar stored up in the muscles was heavily drawn upon by exhausting labor. At such a time the rapidity with which sugar is digested and absorbed proves a great advantage.

In effect Dr. Schumberg says: "The practical conclusion to be drawn is that sugar in small doses is well adapted to help men to perform extraordinary muscular labor." He advises practical tests of his results on a large scale in which small amounts of sugar in some refreshing drink, as lemonade, will be given to men fifteen or twenty minutes before they begin a piece of very hard work or at the first signs of exhaustion. If the sugar is to be taken in solid form he recommends chocolate as the best medium. The application of these results to the food of soldiers who may be called upon for extraordinary exertion in marching or fighting is very evident.

Following on this work of Schumberg's came a practical test made with soldiers of the German army during the autumn maneuvers, the observation extending over thirty-eight days. A number of men were given 10 lumps (70 grams, or about one-sixth pound) of sugar daily and were compared in various ways with men performing the same amount of work in marching and drilling, but whose food contained little or no sugar. The results were in every way to the advantage of the men using sugar. The sugar was relished during the whole time. On long marches it appeased hunger and mitigated thirst; a feeling of refreshment followed which helped the tired man on his way, and none of the soldiers allowed sugar were at any time overcome by exhaustion. It was found that both their pulse rate and breathing were less affected by exertion than was the case with the men consuming no sugar. On the basis of these results the military surgeon making the investigation recommended that the sugar ration for soldiers be raised to 60 grams daily, and that it be furnished as sugar for coffee and in sweetened food, preserves, or honey. It was recommended, further, that sugar be supplied to prisons, hospitals and ships, its fine keeping qualities and condensed form making it especially valuable in certain cases. The value of glucose as a muscle food has been recently shown by methods similar to Schumberg's.

It is believed that more satisfactory results may be obtained by experiments with men and animals in which the effects of given quantities of sugar in the diet are compared with those obtained with starch and other food materials. Such experiments with men in the respiration calorimeter are now being made under the auspices of this Department. They make it possible to measure with great accuracy the relation between the material consumed and the muscular work done.

According to our present knowledge, the value of sugar as a food for muscular work may be briefly summarized as follows:

(1) When the organism is adapted to the digestion of starch, and there is sufficient time for its utilization, sugar has no advantage over starch as a food for muscular work except as a preventive of fatigue.

(2) In small quantities and in not too concentrated form sugar will take the place, practically speaking, weight for weight, of starch as a food for muscular work, barring the difference in energy and in time required to digest them, sugar having here the advantage.

(3) It furnishes the needed carbohydrate material to organisms that have as yet little or no power to digest starch. Thus, milk sugar is part of the natural food of the infant.

(4) In times of great exertion or exhausting labor, the rapidity with which it is assimilated gives it certain advantages over starch.

This latter quality, which renders it more rapidly available for muscle force, may, perhaps, account for the fact that sugar is so relished by people who are doing muscular work and by those of very active habits, as children.

The American farmer ranks high among agriculturists as a rapid and enduring worker, and his consumption of sweets is known to be very large. The same is true of lumbermen and others who work hard in the open air. Col. Henry Browne, quoted by Dr. Harley, says:

> The lumbermen of Canada, than whom no finer or more muscular men exist, eat a great deal of sugar in the form of molasses. They fill their milkless tea with it, make cakes with it, and even add it to their fried fat salt pork, which is the only meat they get during the whole time they are in the woods cutting lumber, and this is practically half the year, their diet when at home being much the same.

In connection with the nutrition investigations carried on by this Department the dietary of the negroes in Alabama on the edge of the so-called "black belt" was studied. The staple articles of diet were found to be salt pork, corn meal, and molasses. The molasses was made from sorghum or sugar cane. It was often a domestic product. When this supply was not sufficient a commercial molasses was purchased. Molasses was eaten mixed with the fat obtained when fat salt pork was fried. This mixture, with corn bread and fried pork, formed the basis of the regular diet for each meal every day in the year, some green vegetables being occasionally added. Hot water sweetened with molasses was the beverage used with the meals. It should be added that this diet was not considered satisfactory by those making the investigation, it being deficient in nitrogenous material.

The value of sugar in cold climates, where foods containing starch are not produced or can not be kept, is evident. In the outfit of polar expeditions sugar is now given an important place, and it may, in time, take the place of part of the large amount of fat eaten by the Eskimos and other inhabitants of the polar regions.

It is in warm countries, however, that sugar plays the greatest rôle, for there very little fat is eaten. In India it is said that workmen must have, daily, large amounts of food well seasoned with sugar. The employer must furnish it or lose his workmen. In all tropical lands the consumption of dates, figs, and other sweet fruits is very large.

Certain rowing clubs in Holland report very beneficial results from the use of large amounts of sugar in training. It seemed to counteract the bad effects of a meat diet, so that the dreaded symptoms of overtraining did not appear. The rowers who used sugar always won because of superior endurance.

One case as given in detail is very interesting. Two schoolboys, 17 and 19 years of age, with only two hours a day for practice, at the end of two months entered for the rowing races. No change had been made in their diet except that they ate as much sugar as they wished, sometimes as much as one-third of a pound at the time of their daily exercise. One of them, however, did not make this addition to his diet until the third week, when he began to show all the signs of overtraining—loss of weight, and a heavy, dull feeling, with no desire for study. On the third day after beginning the use of sugar these symptoms disappeared. At the time of the race both youths were in fine condition and were victorious over their antagonists, who did not believe in the use of sugar. No after bad effects were observed.

Professor Pflüger says that, without doubt, the sugar in the blood is heavily drawn on during violent exercise; hence the longing for it in a form that can be rapidly assimilated.

Mr. Charles E. Courtney, trainer of the Cornell University boat crew, recently informed the writer that the men in training seemed to crave sugar, and they were allowed all they wanted on cereals, in tea, coffee, etc., but he objected to it in pie and cake.

Its use by mountain climbers is well known. The Swiss guide considers lump sugar and highly sweetened chocolate an indispensable part of his outfit.

SUGAR AS A FAT FORMER.

Sugar, like starch, is fattening; that is, when taken in excess it may be transformed into fat and stored as reserve material. On this account physicians advise that sugar be sparingly used by the corpulent.

Both molasses and sugar have been successfully used in fattening cattle and pigs, the fat being found to be firm and of good quality. With cattle, 500 grams a day were profitably eaten.

It is said that in Santo Domingo, at times when the importation of grain has been suspended for lack of ships, raw sugar has been used to fatten horses and cattle for months together.

SUGAR AS A FLAVOR.

As mixed with other foods, sugar is one of our best flavors—a flavor which the cook could not readily spare, as it now enters into a great variety of dishes. Its agreeable flavor has always constituted one of the chief reasons for its use, and will continue to do so, since we have such an abundance of relatively cheap starchy materials which may readily take the place of sugar as food.

In some dietary studies made under the auspices of this Department with a club of students at the Maine State College, the effect was studied of supplying a liberal amount of maple sirup in connection with a diet which was known to furnish an abundance of nutrients. The sirup was evidently relished, and considerable amounts were eaten. However, there was not a corresponding decrease in other foods; on the other hand, the amount of flour was in excess of the amount ordinarily consumed. It would seem that the maple sirup and flour, in the form of griddle cakes, were consumed simply on account of their agreeable flavor. Provided the diet contained sufficient nutrients in the first place, this increase was not desirable on the ground of economy, and it may be questioned whether it was desirable from the standpoint of health. When a similar comparison was made of the addition of milk in liberal amounts to the diet it was found there was a corresponding decrease in the amount of other foods consumed.

This investigation would indicate, as stated above, that sugar is consumed for its agreeable flavor and not because it is recognized as a food.

FOOD VALUE OF MOLASSES.

Besides some cane sugar, molasses contains about 30 per cent invert sugar, about 30 per cent water, and certain acids and other bodies of which we know little. It also contains impurities accidentally present. Molasses was formerly the drainage or refuse from the manufacture of cane sugar, but with modern methods of sugar making this source of supply has become entirely inadequate. Small planters in Louisiana and elsewhere who have a limited tract of cane under cultivation still follow the old method of sugar making without the help of vacuum pan and centrifugal. The molasses drains from the brown sugar and is called "open-kettle" molasses. It commands the highest price on account of its fine flavor, but this variety is almost all consumed in the locality where it is made. Much that is now sold as New Orleans molasses is glucose or starch sugar colored and flavored with some molasses from the sugar factories. Glucose is used to give molasses a body and a lightness of color that is in demand, and this mixture is now preferred quite generally to the old-fashioned dark molasses. In consequence of the preference for a light-colored product, molasses not mixed with glucose is bleached to improve its color. The bleaching agents are generally of a deleterious character and must be very carefully removed when they have done their work. It is the possible presence of these agents, rather than that of glucose, that suggests caution in the use of molasses in quantity. Glucose, as we have already said, if carefully made is not considered injurious.

No molasses for table use is made from the sugar beet, as it is impossible to free the uncrystallizable part from the objectionable impurities. Maple sirup or molasses is the sap of the sugar maple which has been boiled down, but not sufficiently to cause the sugar to crystallize. The high price of maple molasses or sirup has led to extensive adulterations of the product with cane sugar and glucose, the flavor being often furnished by an extract of hickory bark.

In the United States a considerable quantity of molasses is made from sorghum. It is consumed for the most part in or near the locality where it is made.

NUTRITIVE VALUE OF SUGAR CANE.

The entire juice of the ripened cane is of course more nearly a complete food than is crystallized sugar, for it contains other constituents besides carbohydrates. It is elaborated by the plant as a rich plant food used to build up young leaves and buds. In sugar-producing countries the cane is said to be a staple food during its season. All classes of people chew the ripe cane freed from its hard rind, incredible quantities being consumed in this way. Shiploads are brought daily to the markets of Rio Janeiro, New Orleans, and the West India towns. For months the chief food of the negro laborers on the plantations is said to be the sugar cane, and they are seen to grow strong and fat as the season advances. They go through the hard labor of harvesting the crop and come out in fine condition, although they began it weak and half starved.

Wray says: "The nutritious and fattening qualities of the sugar cane are abundantly shown on every sugar estate in the world." Another writer says: "From their free use of the cane juice the negroes of the West Indies and every animal about the plantation at the time of harvest show every indication of the wholesome and nutritious properties of the juice."

A curious book, entitled A Treatise on Sugar, written by Dr. B. Mosely, and published in 1799, has the following:

> In the West Indies the negro children from crude vegetable diet are much afflicted with worms. In crop time, when the canes are ripe, these children are always sucking them. Give a negro infant a piece of sugar cane to suck and the impoverished milk of his mother is tasteless to him. This salubrious luxury soon changes his appearance; * * * his emaciated limbs increase, and if the canes were always ripe he would never be diseased. I have often seen old, scabby, wasted negroes crawl from the hot houses, apparently half dead, in crop time and by sucking canes all day long they would soon become strong, fat, and sleek.

La Gazette de Santé, 1785, narrates that a vessel from the West Indies laden with sugar encountered a calm, which so delayed her that provisions were exhausted. The crew then had recourse to the cargo; some sailors had already died of scurvy and many were threatened with death, but this disease abated when its victims were of necessity reduced to a sugar diet. The sugar in this case was undoubtedly raw or crude sugar, and it may well have had this effect by virtue of the potassium salts contained in it.

PRACTICAL USE OF SUGAR IN DIETARIES OF ADULTS.

Sugar was formerly regarded as a condiment and valued chiefly for its pleasant taste. Had it in reality no other use it might in time be replaced by other sweet-tasting substances, as saccharin and dulcin, which are not foods, but the food value of sugar has been fully established, and, considering the immense quantities at present consumed, it is very important to determine the extent of its usefulness in dietaries.

It has been ascertained that in large numbers of well-to-do families in our country about 2 pounds per week per person is consumed. It would seem that this amount, or about one-fourth of a pound daily, taken as it is in connection with other foods, is well utilized by the system. Regarding larger quantities there is some question. The use of sugar would seem to be limited in two ways: (1) By the fact that sugar may be absorbed more rapidly than it can be assimilated and thus overload the system, bringing on indigestion or overloading the excretory organs; (2) by the ill effects on the system of concentrated solutions of sugar.

AMOUNT AND CONCENTRATION.

Regarding the amount that can be properly used in the system, sugar differs greatly from starch. Starchy food, as bread, potatoes, etc., can be digested and utilized in immense quantities. Rubner reports that food containing over 600 grams (1⅓ pounds) of starch a day is digested without difficulty and over considerable periods of time. This amount of starch would be represented by 2½ or 3 pounds of bread or 6 or 7 pounds of potatoes.

Fewer tests have been made regarding the maximum amount of sugar that may be used by the system. Vaughan Harley used large quantities of sugar in his experiments already quoted, but 400 grams (nearly a pound) daily for some time very much affected his digestion.

Since, as scientific investigators seem agreed, the digestion of sugar is much more rapid than that of starch, assimilation and storage in the liver can not keep pace with its absorption in the intestines if it is taken in large quantities. In this case part of the sugar will be excreted unchanged. Not only is this excess of sugar wasted, but such an unnatural tax on the excretory organs would soon end in disease. It is also a matter of common observation that large amounts of sugar and sweetened food are apt to ferment in the stomach and intestines. This prompt refusal of the system to utilize large amounts of sugar at a time is a sign that must be heeded. It shows that the eating of sugar can easily be carried too far.

It has been pointed out by investigators that in this regard sugar bears much the same relation to starch that peptone, one of the products of meat digestion, does to meat. Both sugar and peptone are very diffusible, and thus enter rapidly into the circulation, strong solutions at the same time irritating the mucous membrane with which they come into contact by virtue of their water-abstracting power. In cases of weak digestion peptone and albumoses, or meat artificially digested, is given, that the system may be nourished with as little tax as possible on the digestive organs. But in the case of a man in health, if the peptone is substituted entirely for the natural food it brings on irritation of the intestinal canal, with diarrhea and other symptoms of indigestion.

Brandl, a German scientist, made experiments on the effect of sugar solutions of different strengths on the stomach of a dog. A solution of 5.7 per cent reddened the mucous membrane; a 10 per cent solution made it dark red, indicating great irritation; a 20 per cent solution caused the dog such distress that the experiment was carried no further. It is quite possible that this effect is produced on the human stomach when large quantities of sugar in concentrated form, as candy, are eaten.

Chaveau, a French investigator, in his experiments with dogs, found that when used in considerable amounts sugar was so laxative in its effects as to interfere greatly with his work; yet he found, as have others, that sugar was a source of energy, and his conclusion was that it has a higher value as compared with fat than is ordinarily assigned to it. It must be remembered that sugar is a powerful antiseptic or germicide. In a strong sirup of sugar fruits, vegetables, and even meats may be preserved. This property of sugar was well understood when it was used only as a medicine, for it was even sprinkled on wounds to keep them from mortifying. An agent of this kind in concentrated solution must not only hinder putrefactive processes, but also retard the process of digestion. Thus, Ogata found in experiments with dogs that the addition of 10 grams of cane or grape sugar to 100 grams of meat fibrin caused 18 to 27 per cent of it to remain undigested as compared with normal digestion. With our present understanding of the amount of absorption going on in the stomach, we can not state positively that such a delay is in itself disadvantageous.

It will be noticed that sugar as it exists in nature—e. g., in the sugar cane, in milk, and in most fruits—is not highly concentrated. In milk it makes up from 4 to 6 per cent. It would seem that the animal organism is best adapted to the utilization of food principles in the somewhat dilute or bulky form in which they occur in the commonly accepted foods—protein as found in meat, milk, etc., starch in grains, and sugar in small quantities as found in vegetable juices and milk, and in reasonable amounts in combination with other foods—and that it does not readily accept unlimited amounts of chemically isolated and purified food principles.

BAD EFFECTS ASCRIBED TO SUGAR.

Most of the bad effects ascribed to sugar are due to its use in larger quantities than the 3 or 4 ounces a day which seem to be digested by the healthy adult without difficulty, if it is not presented in indigestible forms. There is no proof that sugar is harmful to the teeth, although doubtless sweet food, allowed to cling to the teeth after eating, rapidly ferments and acids will be formed that, according to Professor Miller, of Berlin, may attack the teeth. This is equally true of starchy foods. It is said, however, that the negroes of the West Indies, who consume enormous quantities of sugar, have the finest teeth in the world.

It is also unproved that sugar produces gout.

Sugar seems ill adapted to the sick, except when used in very small quantities as a flavor. Jacobi remarks that in sickness the stomach is inactive, has less absorptive power, and that sugar on that account is less well borne. The action of sugar in stimulating a flow of the digestive juices may in such a case be only irritating in its effect.

EFFECT OF EXERCISE ON THE AMOUNT OF SUGAR WHICH MAY BE EATEN.

The amount of sugar that may be eaten without bad effects depends much on whether a person leads an active or a sedentary life. It has been observed that a man doing hard work in the open air can easily assimilate large amounts of sugar, while the same quantity would bring on indigestion if taken when he is living indoors, with little exercise.

SUGAR IN COOKED FOODS.

What has been said of the food value of sugar applies to it as a solution in water and in various drinks, as tea, coffee, etc. The food value of sugar as taken in cake, pastry, custards, and other cooked foods is probably somewhat modified; but few tests have been made in the digestibility of such foods.

CONFECTIONERY.

Candy of the better grade is very largely made up of sugar, with the addition of various coloring matters and flavors, nuts, fruit, etc., and sometimes fat, starch, and glucose. The food value of candy may be expressed by the amount of the sugar contained (72 to 96 per cent), but the wholesomeness of the other ingredients must be taken into account. The coloring matters used in cheap candies are nearly all compounds of anilin or other coal tar products, some of which are thought to be harmless, while regarding others there is more doubt. Two hundred and fifty samples of cheap candy examined by the Division of Chemistry of this Department a few years ago were found to be made up largely of glucose with a little sugar and starch. Pure glucose is no longer considered an injurious adulterant. Some of the coloring matters and flavors used, however, have been shown to be harmful. Ordinary caution would suggest that children, at least, be allowed to partake very sparingly of such unknown compounds. It is to be remembered also that glucose, being more rapidly absorbed than is cane sugar, may overload the system more easily. It also undergoes fermentation more readily.

SUGAR IN THE DIETARIES OF CHILDREN.

The amount of sugar to be given to children, and in what form, is a question of much importance. Sugar would seem to be a food especially adapted to children because of their great activity. The small organism loses more heat from the skin for every pound of body weight than does the larger animal, and children on this account, and because of their active life, require proportionately more heat units in their food than do adults.

Fat, especially fat meat, which could readily supply this need, is often disliked by the child, and his relish for all kinds of sweets has doubtless a physiological basis. It is, however, to be remembered that before its introduction countless generations of children had been reared without the help of cane sugar as we now know it. The digestibility of sugar and sweetened foods for children, and the influence on the appetite for other foods, must decide to what extent sugar is to replace starch in the dietary and how far it may be safely used as a flavor.

Until a child's stomach is capable of digesting starch the needed carbohydrate is furnished in the sugar of milk, the child a year old who drinks two quarts of milk a day taking in this way about three ounces of sugar. As the stomach becomes able to digest starch the child is less and less dependent on the sugar of milk, replacing it with the carbohydrates of vegetable origin, while the proteids and fat found in eggs, meat, and cereals take the place of those constituents that were at first exclusively furnished in milk. Milk, however, remains through childhood a valuable source of all these food principles.

The fact that sugar has a high food value is not the only point to be considered. The child will easily obtain the needed carbohydrates in other forms and will thrive if the digestion remains sound and its relish for wholesome food unimpaired. For instance, one often hears it said that a certain child does not relish milk. In such cases it might be found that the child's appetite, being sated by sugar in other foods, is no longer attracted by the mild sweetness of fresh milk, delicious as it is to the unspoiled palate. It would be well, perhaps, in this instance, to cut down the allowance of sugar in the hope of restoring the taste for so invaluable a food as milk. Dr. Rotch insists that the infant, even in its second year, should never be allowed to taste sweets. He says, "When these articles are withheld it will continue to have a healthy appetite and taste for necessary and proper articles of food."

Even much later, for the same reasons, the introduction of large amounts of sugar into the daily food of children is to be carefully considered. Children do not require a variety of flavors to stimulate the appetite, but the taste is easily perverted and the backward step is difficult to take. Those who have studied the food habits of children seem to agree that sugar should from the very first be withheld from the dish that forms the staple food of the child—that is, the mush or porridge of oatmeal or some preparation of wheat or corn. This article of diet, eaten only with milk or cream, falls into the same class as bread and milk, and forms the simple, wholesome basis of a meal. The sugar given the child is better furnished in the occasional simple pudding, in the lump of sugar, or homemade candy, not that its food value is better utilized, but the whole food of the child is thus more wholesome.

In sweet fruits fully ripened the child finds sugar in a healthful form and they should be freely furnished.

GENERAL CONCLUSIONS.

One may say in general that the wholesomeness of sweetened foods and their utilization by the system is largely a question of quantity and concentration. For instance, a simple pudding flavored with sugar rather than heavily sweetened is considered easy of digestion, but when more sugar is used, with the addition of eggs and fat, we have, as the result, highly concentrated forms of food which can be utilized by the system only in moderate quantities and which are always forbidden to children and invalids.

It is true that the harvester, lumberman, and others who do hard work in the open air consume great amounts of food containing considerable quantities of sugar, such as pie and doughnuts, and apparently with impunity; but it is equally true that people living an indoor life find that undue amounts of pie, cake, and pudding, with highly sweetened preserved fruit, and sugar in large amounts on cooked cereals, bring indigestion sooner or later.

From a gastronomic point of view it would seem also that in the American cuisine sugar is used with too many kinds of food, with a consequent loss in variety and piquancy of flavor in the different dishes. The nutty flavor of grains and the natural taste of mild fruits is concealed by the addition of large quantities of sugar.

In the diet of the under nourished larger amounts of sugar would doubtless help to full nutrition. This point is often urged by European hygienists. In the food of the well-to-do it is often the case, however, that starch is not diminished in proportion as sugar is added. That sugar on account of its agreeable flavor is a temptation to take more carbohydrate food than the system needs can not be denied. The vigor of digestion in each particular case would seem to suggest the limit. A lump of sugar represents about as much nutriment as an ounce of potato, but while the potato will be eaten only because hunger prompts, the sugar, because of its taste, may be taken when the appetite has been fully satisfied.

Sugar is a useful and valuable food. It must, however, be remembered that it is a concentrated food and therefore should be eaten in moderate quantities. Further, like other concentrated foods, sugar seems best fitted for assimilation by the body when supplied with other materials which dilute it or give it the necessary bulk.

Persons of active habit and good digestion will add sugar to their food almost at pleasure without inconvenience, while those of sedentary life, ot delicate digestion, or of a tendency to corpulency would do better to use sugar very moderately. It is generally assumed that 4 or 5 ounces of sugar per day is as much as it is well for the average adult to eat under ordinary conditions.

FARMERS' BULLETINS.

The following is a list of the Farmers' Bulletins available for distribution, showing the number, title, and size in pages of each. Copies will be sent to any address on application to Senators, Representatives, and Delegates in Congress, or to the Secretary of Agriculture, Washington, D. C.:

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52. The Sugar Beet. Pp. 48.
53. How to Grow Mushrooms. Pp. 20.
54. Some Common Birds. Pp. 40.
55. The Dairy Herd. Pp. 24.
56. Experiment Station Work—I. Pp. 31.
57. Butter Making on the Farm. Pp. 16.
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62. Marketing Farm Produce. Pp. 28.
63. Care of Milk on the Farm. Pp. 40.
64. Ducks and Geese. Pp. 48.
65. Experiment Station Work—II. Pp. 32.
66. Meadows and Pastures. Pp. 28.
67. Forestry for Farmers. Pp. 48.
68. The Black Rot of the Cabbage. Pp. 22.
69. Experiment Station Work—III. Pp. 32.
70. Insect Enemies of the Grape. Pp. 23.
71. Essentials in Beef Production. Pp. 24.
72. Cattle Ranges of the Southwest. Pp. 32.
73. Experiment Station Work—IV. Pp. 32.
74. Milk as Food. Pp. 39.
75. The Grain Smuts. Pp. 20.
76. Tomato Growing. Pp. 30.
77. The Liming of Soils. Pp. 19.
78. Experiment Station Work—V. Pp. 32.
79. Experiment Station Work—VI. Pp. 28.
80. The Peach Twig-borer. Pp. 16.
81. Corn Culture in the South. Pp. 24.
82. The Culture of Tobacco. Pp. 24.
83. Tobacco Soils. Pp. 23.
84. Experiment Station Work—VII. Pp. 32.
85. Fish as Food. Pp. 30.
86. Thirty Poisonous Plants. Pp. 32.
87. Experiment Station Work—VIII. Pp. 32.
88. Alkali Lands. Pp. 23.
89. Cowpeas. Pp. 16.
90. Superseded by No. 135.
91. Potato Diseases and Treatment. Pp. 12.
92. Experiment Station Work—IX. Pp. 30.
93. Sugar as Food. Pp. 27.
94. The Vegetable Garden. Pp. 24.
95. Good Roads for Farmers. Pp. 47.
96. Raising Sheep for Mutton. Pp. 48.
97. Experiment Station Work—X. Pp. 32.
98. Suggestions to Southern Farmers. Pp. 48.
99. Insect Enemies of Shade Trees. Pp. 30.
100. Hog Raising in the South. Pp. 40.
101. Millets. Pp. 28.
102. Southern Forage Plants. Pp. 48.
103. Experiment Station Work—XI. Pp. 32.
104. Notes on Frost. Pp. 24.
105. Experiment Station Work—XII. Pp. 32.
106. Breeds of Dairy Cattle. Pp. 48.
107. Experiment Station Work—XIII. Pp. 32.
108. Saltbushes. Pp. 20.
109. Farmers' Reading Courses. Pp. 20.
110. Rice Culture in the United States. Pp. 28.
111. Farmers' Interest in Good Seed. Pp. 24.
112. Bread and Bread Making. Pp. 39.
113. The Apple and How to Grow It. Pp. 32.
114. Experiment Station Work—XIV. Pp. 28.
115. Hop Culture in California. Pp. 27.
116. Irrigation in Fruit Growing. Pp. 48.
117. Sheep, Hogs, and Horses in the Northwest. Pp. 28.
118. Grape Growing in the South. Pp. 32.
119. Experiment Station Work—XV. Pp. 31.
120. Insects Affecting Tobacco. Pp. 32.
121. Beans, Peas, and other Legumes as Food. Pp. 32.
122. Experiment Station Work—XVI. Pp. 32.
123. Red Clover Seed: Information for Purchasers. Pp. 11.
124. Experiment Station Work—XVII. Pp. 32.
125. Protection of Food Products from Injurious Temperatures. Pp. 26.
126. Practical Suggestions for Farm Buildings. Pp. 48.
127. Important Insecticides. Pp. 42.
128. Eggs and Their Uses as Food. Pp. 32.
129. Sweet Potatoes. Pp. 40.
130. The Mexican Cotton Boll Weevil. Pp. 30.
131. Household Test for Detection of Oleomargarine and Renovated Butter. Pp. 11.
132. Insect Enemies of Growing Wheat. Pp. 40.
133. Experiment Station Work—XVIII.
134. Tree Planting in Rural School Grounds.
135. Sorghum Sirup Manufacture.
136. Grape Culture in the North.
137. The Angora Goat.
138. Irrigation in Field and Garden.

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U. S. DEPARTMENT OF AGRICULTURE.

FARMERS' BULLETIN No. 94.

THE VEGETABLE GARDEN.

BY

CHARLES H. GREATHOUSE, A. M.,
Division of Publications.

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LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Division of Publications,
Washington, D. C., March 28, 1899.

Sir: I have the honor to transmit herewith for publication as a Farmers' Bulletin an article entitled The Vegetable Garden, prepared by Mr. C. H. Greathouse, of this Division. There has long been a demand for information on gardening, which the present bulletin aims to give in a few concise suggestions in regard to cultivation and care of the most common vegetables, whether in the farm garden or in the less pretentious garden plot of the city or suburban resident.

In the preparation of the bulletin this Division has been greatly aided by Mr. William Saunders, Superintendent of Gardens and Grounds, who kindly afforded the author the benefit of his wide experience. When completed, the bulletin was submitted to him and has received his approval. Much help has also been gained from Prof. L. H. Bailey's book, Garden-making.

Very respectfully,

Geo. Wm. Hill, *Chief.*

Hon. James Wilson, *Secretary.*

CONTENTS.

Page.
Importance to farmer 3
Location 3
Drainage 4
Preparation of the soil 5
  Plowing 5
  Use of fertilizers 6
Supply of seeds and young plants 8
  Quantity and quality 8
  Plants from the hotbed 9
Planting 10
  Marking the rows 12
  Condition of the soil 12
  Depth of planting 12
  Transplanting 13
  Rotation 13
Cultivation 13
  Time for the soil mulch 14
  Irrigation 14
  Killing the weeds 15
Insecticides 15
Specific directions for several vegetables 15

ILLUSTRATIONS.

1. Use of spade in ditching 4
2. Vertical section of soil well prepared 5
3. Vertical section of soil poorly prepared 6
4. Section of hotbed 9
5. Tracy's plan for kitchen garden 11
6. Jerusalem artichoke, whole plant and tubers 16
7. Ground cherry 20
8. Martynia 20

THE VEGETABLE GARDEN.

IMPORTANCE TO THE FARMER.

The farm garden probably pays better than any other land on the place. No figures have ever been collected to show of what value its products are, but in the census of 1890 full statistics for market gardens were obtained and from these the conclusion just stated may be argued. The average value of garden stuff to the acre was found to be $147.17, while for wheat the average was only $11.65. Later reports show that the average for wheat, corn, oats, and hay is $7.75 per acre. It seems clear, therefore, that market gardening is more profitable than farming. But the home garden must pay even better than the market garden, for it is not subject to the heavy losses incident to marketing perishable crops. Its products are used directly on the home table and there need be very little waste. It follows that the garden pays better than the field. A good garden will supply half the family's living, and when field crops show a balance on the wrong side it becomes a very important means of support.

In addition to this the garden may be a bountiful source of quiet pleasure. A keener appreciation of such natural joys of the farm home and skill to develop them would do much to repress the craving for excitement which draws young men from country life.

LOCATION.

The garden is frequently under the care of the farmer's wife. It should be in such case as near as practicable to the kitchen, so as to be in easy reach for gathering the vegetables and for fifteen-minute opportunities for gardening. Also all heavy crops, as potatoes, melons, squash, and cabbage, must then be put in the field, where they can be cultivated with horse and plow.

Further, the site should be chosen with reference to sun and wind. A surface that slopes gently to the south is to be preferred, and if the incline looks a little to the east it is the better for it. A woodland or high hill as protection from the north winds and heavy storms is a great advantage, and equal or better will be a wall or hedge judiciously placed as a wind-break. It should usually be on the north or northwest in this country. A wire netting or high paling fence will be needed to keep out the chickens, if any are on the place.

Finally, soil and natural drainage must be considered in selecting the location. A light sandy loam is usually preferred, but fine vegetables are grown with ordinary care on heavy dark soils, on sticky red clays, and on sands apparently no better than the seashore. A mellow rich soil which will hold moisture well is easily recognized, and should be chosen if available; but hardly any soil need be rejected as impracticable until tried. Good natural drainage should be sought. Marshy or even damp ground will call for much labor and expense to make it fit for use. The character of natural drainage can best be determined by observation of the lay of the ground, of the appearance of the soil, and of the vegetation it has borne.

The size of the garden plot should depend on the size of the family and their taste for vegetables; also upon what vegetables are to be grown as field crops. A quarter of an acre is considered sufficient for a garden for a family of four. If potatoes, cabbage, corn, and melons are to be grown in it this estimate is hardly sufficient; but if these vegetables are put in the field, as they should be, usually less than half an acre will be enough, giving room for early potatoes and sweet corn. The best shape is rectangular (see plan, page 11).

DRAINAGE.

When the size and place for the garden have been determined, attention should be given to the drainage, unless it is naturally very good indeed. The purpose is to get rid of an excess of water, which, left alone, cuts off the supply of air from the roots of the vegetables and stops their growth. The work must be done thoroughly before planting; afterwards no remedy can be found for a failure.

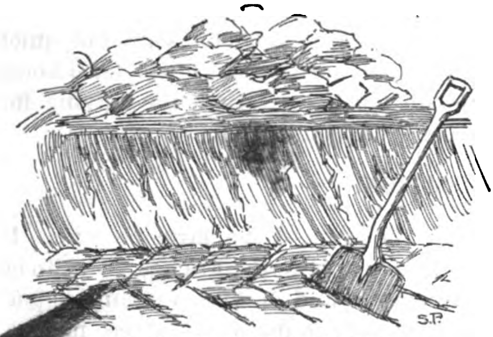

FIG. 1.—Use of spade in ditching.

Surface drainage is frequently secured by use of beds raised above the level of the ground. While this plan has disadvantages, it is commended where no other seems practicable.[1]

But really effective drainage must be underground, and tile drains are usually most economical. Where tile can not be had, stones or brush may be placed in the bottom of the ditch. For most soils the ditches should be 3 to 4 feet deep and about 30 feet apart. They should have plenty of fall and be carefully leveled at the bottom. When the ditch is ready to fill, sods, straw, or paper should be put over the tile or stones to keep out the loose earth. A ditch can be dug in most soils with a spade alone if the digging is done so as to leave one edge of the spade free, as shown in fig. 1. This method of digging of course gives an advantage also in spading a hard soil for beds or other use.

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[1] F. H. Burnette, horticulturist at the Louisiana Experiment Station, writing in Bailey's Garden-making for Southern Gardens, says: "Vegetable seeds of all kinds should always be sown on slight ridges on all but very sandy soils. If the seed be sown on a level bed, as practiced at the North, the ground will become as hard as a turnpike road should a heavy rain occur."

Trenching will often take the place of drains. This consists of breaking up the soil two spades deep instead of one. From the top a spadeful of earth is thrown out and then the subsoil to an equal depth is cut, but is not taken out and turned over. It is only lifted up a little and allowed to drop back into its place. This must be done, however, in a way to break up the earth thoroughly. Trenching needs to be done only every two or three years. It is especially useful when the subsoil is very hard or comes near the surface. Thorough subsoil plowing renders trenching unnecessary.

PREPARATION OF THE SOIL.

The ground is made ready for planting by plowing, harrowing, rolling, and fertilizing. Spading may be done for a small garden or where special preparation is required for a limited space. The rake is usually employed in finishing off the beds. The soil should be broken fine as deep as the plant roots may be expected to go. This is from 15 to 20 inches. The earth is left fine, loose, and mellow far down, so the tender roots may grow through it freely. It then holds moisture and lies close to the roots, so as to supply them readily with food. The accompanying illustrations from Bailey's Garden-making (figs. 2 and 3) will aid in understanding the breaking up of the soil desired.

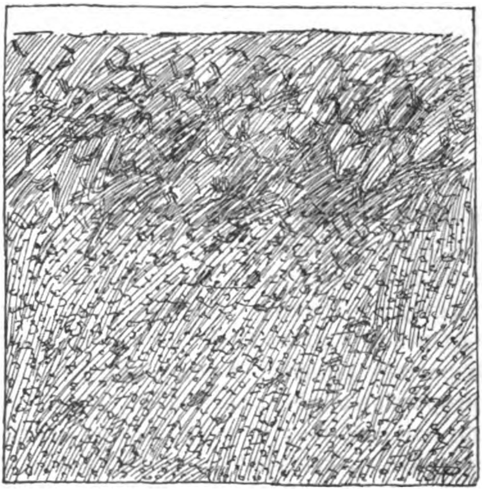

FIG. 2.—Vertical section of soil well prepared.

PLOWING.

The fall is the time for plowing in any hard or cloddy ground, especially in stiff clays. The clods are left exposed to the frost, which is nature's most effective agent in opening up soil and putting it in order for plant growth. A stiff clay thrown on edge by the plow will break up during the winter into a mass of fine-grained material, almost as open as sand and well adapted to growing vegetables. But if the breaking is left till spring, or if the ground broken in the fall has become compacted during the winter, the plow should be set deep, and harrowing and rolling continued until a fine, loose condition is secured. As a rule, two plowings will be better than one and three better than two. Prepare the soil thoroughly before planting. Neglect of this will be felt all through the season. After the plants are growing it is too late to work the ground beneath them.

The time to plow in the spring is as soon as deep freezing has ceased and the ground is in condition to be worked. The proper condition for working can be determined by squeezing a little of the soil in the hand. If it makes a ball, and sticks to the hand, it is too wet; if it breaks hard, it is too dry. To work well, either for plowing or hoeing, it should crumble easily and finely, and leave very little dirt on the hands.

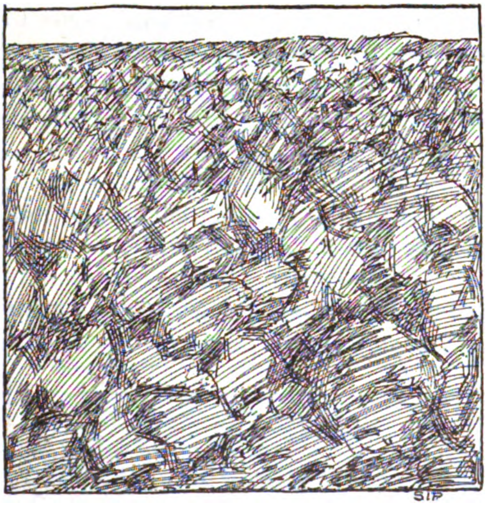

FIG. 3.—Vertical section of soil poorly prepared.

USE OF FERTILIZERS.

Of leading importance in preparation of the ground is the supply of plant food, of which the chief essentials are nitrogen, phosphoric acid, and potash. It is important that any fertilizer used to supply these elements should be thoroughly distributed through all the soil to be reached by the roots of the plants, and this distribution must be completed before planting. Turning and returning the ground and harrowing again and again are useful for the purposes.

A wise selection of fertilizers can not be secured by rule; it is very largely a matter of experience. A sandy soil is often deficient in the essentials of plant food, while a clayey soil contains them in abundance, especially potash. A limestone soil is likely to contain a considerable proportion of phosphoric acid. What is good fertilization on a given soil for one crop may be very unsatisfactory for another. Where it is the purpose to establish a garden permanently, it will be profitable to determine the need of the soil for fertilization by close observation of results from year to year. It will be well to make notes of important points. Not only will the facts thus gained be useful for future gardening, but they will often find application in the larger operations of the field.

Most soils are benefited by the addition of humus, a name applied to any thoroughly rotted vegetable or animal matter. Humus may be known by burning a small quantity of soil on a red-hot shovel. If it gives an odor of feathers, it contains humus from animal matter; if an odor of straw, it contains humus from vegetable matter. Humus forms the richness of nearly all good land, and rarely is there too much of it. In close-grained, sticky soils, which have a tendency to bake, the humus produces a looser texture and a better balance in the retention of moisture. On a loose and leachy soil it brings the grains closer together and promotes chemical activity. At the same time it supplies plant food. Leaves, garden refuse, and barnyard manure made into a compost and allowed to decay make good humus. The pile must be turned over several times each year until it is thoroughly broken up into a mass of even texture.

Lime may be very often added to a soil with good results. It corrects acidity, makes clay soil more friable, and holds sand closer together.

The time for putting on fertilizers depends upon the character of the soil and of the fertilizer. Stable manure may be spread evenly over the surface a short time before the first plowing. It is generally stated that manure should be thoroughly rotted or "short" when applied, but it is considered a good practice to haul it directly from the stable during the winter and scatter it on the ground where it is to be used. In this way the liquid portions are more fully available. The principal advantage in rotting manure before applying it is that the rough litter, the straw, etc., is well broken up, and so the mechanical condition of the soil is improved by its application. The crop to be grown must often be considered in determining how thoroughly rotted the manure should be. It must be remembered that it takes more time for vegetable tissue to be broken up than it does for animal tissue.

Wood ashes are a common and ready source of potash, and in addition improve the mechanical condition of most soils. The lime in them tends to correct "sourness" and to promote the important chemical process of nitrification. Ashes are usually found to render light, sandy soils more moist. Cotton-hull ashes are also very useful, furnishing potash and phosphoric acid.

A valuable means of improving the soil is by growing clover and cowpeas and turning them under. Benefit is also derived by growing peas and beans and other leguminous plants. They collect nitrogen about their roots and it is left in the soil.

Some commercial fertilizers are harmful to certain crops, and care must be taken by inexperienced persons that a wrong use is not made of them. Chemical fertilizers may be applied much nearer the time at which they are to be used by the plant. Bellair, a French authority, says for deep-rooted plants, fertilizers should be put on in the spring before breaking the ground; for shallow-rooted plants, after breaking.

Fuller details as to improvement of soil may be found in the following Farmers' Bulletins: No. 21, Barnyard Manure; No. 44, Commercial Fertilizers; and No. 77, Liming of Soils.

SUPPLY OF SEED AND YOUNG PLANTS.

Seeds should be ready by the time the ground is prepared. It is usually considered enough to send to some reputable dealer and depend upon him for quality. But it is so important to have good seed and mistakes are so easy that careful examination of the seed some time before planting is advisable.

QUALITY AND QUANTITY.

It has been found by experiment in the Department of Agriculture[1] that large, heavy seeds produce stronger plants than do small, light seed. It is always a mistake to plant old seed, and often it is well to procure a supply from a different part of the country, but not very remote nor too different in climate. In this way the tendency of cultivated plants "to run out"—i. e., to go back to the wild state from which they have been improved—is counteracted. Seeds of weeds that are hard to kill out are sometimes found in field and garden seeds and precautions must be exercised against them.

The quantity of seed to be used will depend of course upon the amount of ground to be planted, and that again varies with the size of the family and their preferences among vegetables.

A quantity necessary to sow a fixed length of row is stated at the end of directions for soil and cultivation of various vegetables as given on page 15 and following. Reference to this will be helpful in determining how much seed to provide. It is better to have too much than too little.

PLANTS FROM THE HOTBED.

Many vegetables, as tomatoes and cabbage, must be started in the hotbed and the plants reset once or twice. Such plants can usually be purchased of seed dealers or experienced gardeners in the neighborhood. Enough for a small family may be started in a good-sized box of earth in a south window. But a hotbed (fig. 4) and cold frame are not hard to make. They should be located in a sheltered, dry place, such as a gentle slope on the sunny side of a barn.

The essentials for a hotbed are bottom heat, protection on all sides, and a sash of glass as cover. The heat is usually supplied by the fermentation of horse manure. The manure should be taken fresh, with about half as much of the straw or litter used as bedding as there is of manure. It is piled in a long heap about 4 feet high with the top level. If kept under cover, the manure will be more effective. The pile should be rather narrow for convenience in handling. If fermentation does not start readily, wetting with hot water will start it. The heap should be turned several times at intervals to insure uniform fermentation. In turning any lumps should be broken up and the warmer portions mixed through the heap. When the fermentation has well filled the entire heap, the hotbed may be made.

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[1] Yearbook, 1896, p. 305.

The pit for the hotbed is 1 to 3 feet deep. It may well be built for permanent use, and then brick walls are economical. Board walls are as good as long as they last. Good drainage is essential. The pit should be filled with litter during the winter to prevent freezing on its inner surface. This is especially true if plants are to be started in winter. The litter is thrown out when the time comes to make the bed. Then an inch or two of coarse stuff is put at the bottom, and upon this 18 inches to 3 feet of manure is placed. Next comes a layer of leaf mold and on top 4 or 5 inches of fine garden loam.

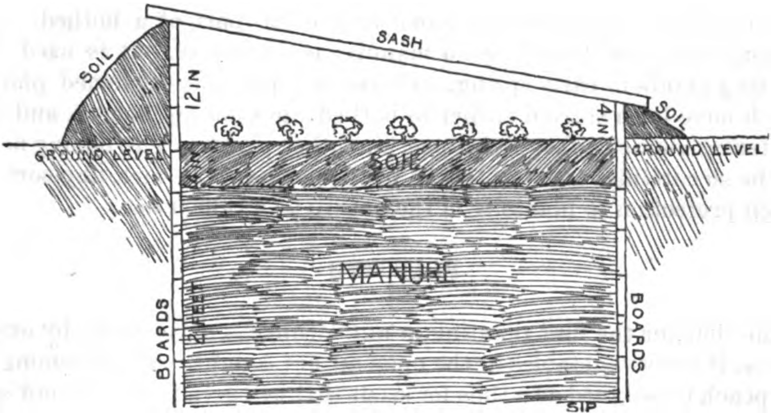

Fig. 4.—Section of hotbed.

The manure should be trodden down in layers about 6 inches thick. If it is loose and fluffy after being trodden, there is too much straw in it; if it packs soggy and solid under the foot, there is too little straw. It should feel springy when trodden, but should not swell up quickly in a loose mass when released from pressure. A hotbed with 2 feet of manure in it may be expected to be good for six weeks.

Mr. William Saunders, for thirty-four years Horticulturist of this Department, prefers that the pit beneath the hotbed should be only a foot deep, leaving most of the manure above ground. Otherwise the heat is drawn off by the cold earth. It is the practice of some gardeners to make the bed entirely above ground. In that case the frame should be at every point about a foot inside the edge of the manure heap. This form gives an opportunity to add to the sides of the bed when the heat begins to decline.

The frame in either case faces south, and is 6 to 8 inches higher at the back than in front. It is covered with a sash slanting to the front to shed the rain, and so placed that it may be raised or pushed aside to allow ventilation. This sash can usually be bought ready-made 3½ by 6 feet in size, and this fixes the size of one section of hotbed.

Experience enables the farmer to judge by the warmth to his hand when it is time to plant seed in the hotbed. If a thermometer is used, 90° is the temperature for planting tomatoes and other plants requiring much warmth, while 70° to 80° will suffice for others. Not all kinds of seed are to be sown in the hotbed at the same time. Attention must be paid to the time at which transplanting must be done. When the plants are ready to go to the cold frame it is a loss to leave them in the hotbed. But if it is still too cold for them out doors a loss will occur by removing them. Care must be taken not to allow the bed to become too hot when the sun comes out suddenly, and to give plenty of fresh air. Whenever the temperature is above freezing the sash may be removed part way. Water should be given as needed, but in the morning, not at night.

A cold frame is about the same as the top part of a hotbed. No bottom heat, and therefore no manure, is necessary. It is used for starting plants in early spring, for receiving partially hardened plants which have been started earlier in hotbeds and forcing houses, and for wintering young cabbages, lettuce, and other plants. The boxing need not be so carefully constructed as in the hotbed. In fact, any sort of rough protection to plants is in the nature of a cold frame.

PLANTING.

The time for the first planting in any locality is only known by experience, if early vegetables in the open air are sought. The blooming of the peach is assigned as a time for seeds that will germinate in a cold soil and resist a slight frost. Among these are peas, spinach, and onion. When the oak leaf breaks from its bud is suggested for beets, turnips, corn, and tomato. Seeds that thrive only in warmer soil, as beans, cucumber, canteloupe, watermelon, squash, and okra, may be planted when the blackberry is in blossom. The planting must be made, of course, with due consideration of the date when the vegetable is expected to be ready for use, and if a continuous supply is desired through the season several plantings at different dates must be made. These are known as successional plantings. An estimate of the number of days from planting to use is given in directions for culture, page 15 and following.

The garden should be planted, when it is practicable, so as to allow cultivation by plowing. Where this can not well be done, wheel tools will be found a great advantage. Usually there must be some hand weeding, but it should be reduced to a minimum. For this reason the rows should be long and continuous. If enough of one kind of vegetable to make a long row is not wanted, several kinds may be put in the same row. The accompanying illustration (fig. 5) from Bailey's Horticulturist's Rule Book furnishes a plan for such planting as is suggested. The rows are about 100 feet long. It will be convenient to have two narrow footpaths across the garden, dividing it into thirds, but

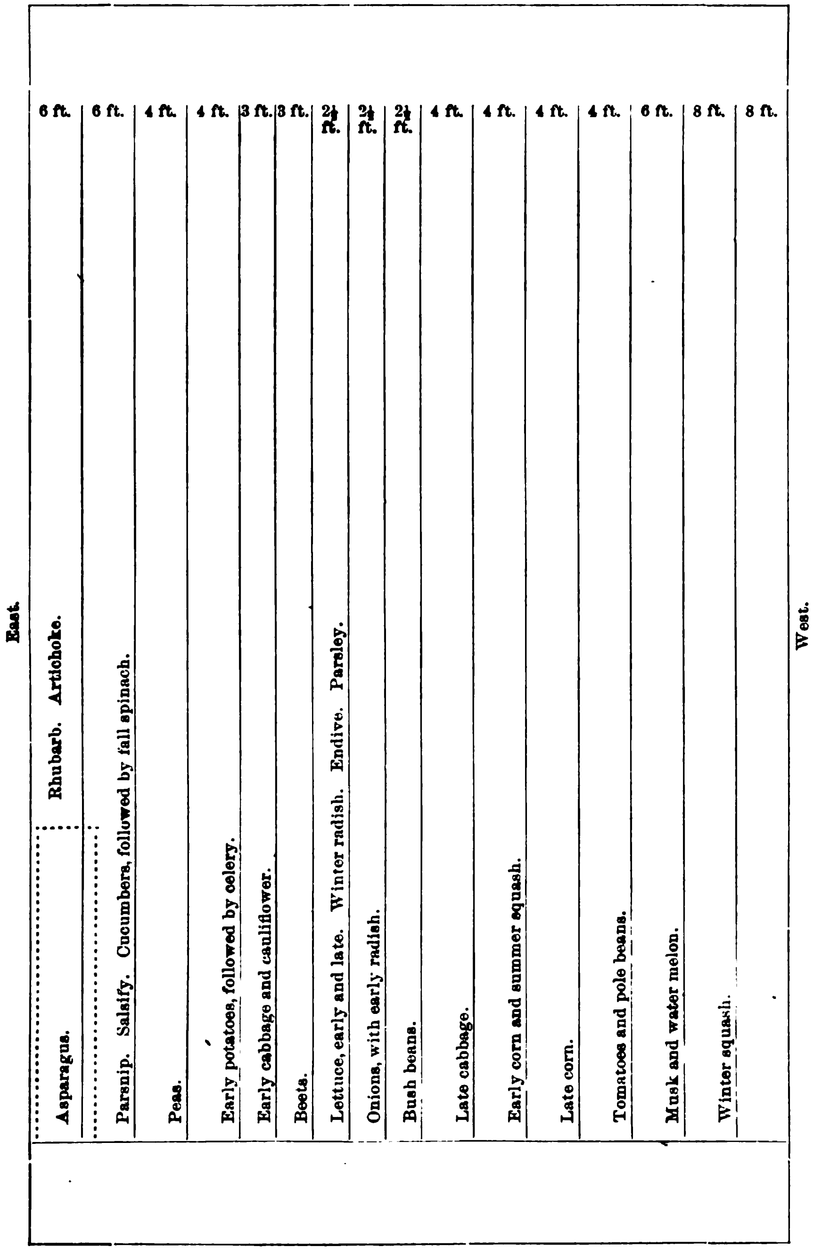
East.
6 ft.
6 ft.
4 ft.
4 ft.
3 ft.
3 ft.
2½ ft.
2½ ft.
2½ ft.
4 ft.
4 ft.
4 ft.
4 ft.
6 ft.
8 ft.
8 ft.
Asparagus.
Rhubarb. Artichoke.
Parsnip. Salsify. Cucumbers, followed by fall spinach.
Peas.
Early potatoes, followed by celery.
Early cabbage and cauliflower.
Beets.
Lettuce, early and late. Winter radish. Endive. Parsley.
Onions, with early radish.
Bush beans.
Late cabbage.
Early corn and summer squash.
Late corn.
Tomatoes and pole beans.
Musk and water melon.
Winter squash.
West.

FIG. 5.—Tracy's plan for kitchen garden.

these need not break the rows so that they can not be plowed or otherwise cultivated throughout their whole length without turning. The direction of the rows east and west is preferred by some.

MARKING THE ROWS.

Various devices have been suggested for marking the rows for planting. A roller, which will serve at the same time as a marker, consists of a smooth, hard-wood log with heavy rope secured firmly about it at distances corresponding to the intervals desired between the rows. When plants or seeds are to be dropped at intervals, the places may be marked by knots in the rope. A roller may be made of a sewer tile by knocking off the collar and filling the hollow with cement. When a marker is not available, the row may be opened with a hoe. A line should be employed to keep the rows straight and parallel to each other; the better results will more than repay the extra trouble.

CONDITION OF THE SOIL.

The soil should be moist when the seed is put in it. Many persons prefer that the planting should be done just before a rain; but in this practice care must be taken against the baking of the soil over the seed. It is usual to firm the earth above the seed by patting it lightly with a hoe or walking over it placing one foot close after the other. This is to make sure that the soil is brought close against the seed. Small, weak seeds must not be put in ground that bakes or is not thoroughly prepared. It is well to sow some large seed of vigorous growth, such as radish or turnip, with celery and other small weak seeds. The added seed come up, breaking the crust, so as to let out the weaker plants. Also they show where the row is, and this makes way for cultivation before the crop is up. Of course the radishes or turnips must be pulled up as soon as the other plants appear. Celery and other seeds that germinate slowly should be shaded.

Most seeds must be sown much more thickly than the plants can be profitably grown. If they come up well thinning is necessary, and this should be done, as a rule, as soon as the first true leaves appear. In thinning care must be observed not to loosen the roots of plants that are left.

DEPTH OF PLANTING.

The depth of cover depends upon the size of the seed, its habits of germination and early growth, the soil, and the season of planting. Planting too deep is a frequent cause of failure to come up. Warmth, air, and moisture are necessary to germination. In the spring moisture is usually abundant, while warmth is lacking. The soil is warmest near the surface. Accordingly the cover should be shallower than in summer, when warmth is abundant and moisture is lacking in the surface soil. A clay soil admits air and warmth less easily than does a sandy soil, and therefore allows less covering. Small, weak seeds should have less cover than large, vigorous seeds. Some kinds, as celery, must be merely pressed into the soil, and have a little sand or dust scattered over them.

Soaking the seed may prove injurious if continued too long, but there is advantage in the case of kinds that are slow to germinate, such as beet, carrot, and parsnip. Also thick skins, as of beans, are loosened by soaking, and the plants will come up probably a day or two earlier.

TRANSPLANTING.

The time for transplanting from the hotbed or cold frame is usually soon after the formation of the first true leaves. The weather should be cloudy or rainy and the ground into which the young plants are to be put should be in the best of condition. The earth should be pressed closely about the roots of the plants in their new place, and if the sun comes upon them they should be shaded with large leaves, shingles, or stones. Small plants may be shaded with screens folded from paper and held in place by stones. If the leaves of the young plants are clipped off about half-way back from the point, the evaporation from them will be lessened that much and the roots will have an opportunity to establish connection with the soil and secure ample moisture before the full demand from the leaves is renewed. By this the plants' chances for living will be materially increased.

Some plants bear transplanting much better than others, but any plant can be removed from place to place at will if the mass of earth about the roots be preserved nearly unbroken in the process.

ROTATION.

Of course the same vegetable should not be grown year after year in the same part of the garden. A proper rotation is comparatively as important in the garden as in the field. Investigation has shown that beans, peas, and other legumes collect nitrogen from the air and leave it in the soil. It follows that deficiency of nitrogen may be supplied by growing leguminous crops, and they may be followed by other vegetables that especially need nitrogen.

Among suggestions for rotation are the following: Lettuce may be succeeded by beans and tomatoes; beans by turnips, radishes, or celery; peas by cabbage or celery; beets by spinach, lettuce, or okra; onions by turnips, peas, beans; cabbage, okra, celery, squash, melons, or cucumbers by beans or peas; corn by melons, cucumbers, squash, beans, or peas.

CULTIVATION.

The chief purposes of cultivation are to keep down the weeds and to maintain in the soil a supply of air and moisture favorable to plant growth.

The moisture in the soil about a vigorous plant is rapidly carried away by evaporation from the leaves. As long as the ground contains an ordinary water supply for several feet below the surface a steady flow of moisture goes upward through the minute spaces between the soil grains. The upper layers of soil are kept from becoming dry by this flow. But when the rainfall is scant the moisture in the lower soil also becomes exhausted and the plant curls up and dwindles. A drought prevails. The gardener must provide against the occurrence of this condition. It is not enough to remedy it; he must prevent it. One of the most efficient means is a mulch, which is most conveniently made of the surface soil.

TIME FOR THE SOIL MULCH.

Usually as soon as a rain is over the atmosphere is free of moisture, and evaporation from the soil sets in. The water that has just soaked in comes up through the little pores between the soil grains and passes off from the surface of the soil into the air. The gardener's aim with the mulch is to save this moisture and send it through his plants. If the little pipes or tubes formed by the pores of the soil are broken, the flow through them is checked and evaporation from the ground is much lessened. It is only necessary then in order to save the moisture for the plants to break up the surface of the soil with a rake or other implement.

It is a serious mistake to suppose that so long as the surface remains moist the soil below is well supplied with water. A damp surface may mean only that moisture is rapidly evaporating into the air. As often as the surface becomes solid it should be stirred with a rake or hoe. As a rain or even a shower compacts the soil at the surface, the common notion that it renders raking or shallow plowing less necessary is precisely contrary to the fact. It is then especially that the surface should be broken. The same is true after irrigation. The raking or plowing should be done as soon as the soil will not cake when squeezed in the hand.

IRRIGATION.

But frequently dry weather continues so long that it is impossible to preserve sufficient moisture by tillage or any sort of mulching. It then becomes necessary to water the garden. Where there is connection with city water works the supply is ample and easily reached. In other locations various forms of cisterns and reservoirs are employed. When it is possible the reservoir should be a few feet above the level, so that any part of the garden can be reached with a hose or a V-shaped trough. The proper application of water appears to be very simple, but is in fact quite difficult.

It is not unusual for an inexperienced person to sprinkle the garden every day or two and think he is relieving the drought. The effect of such treatment is likely to be harmful, especially if the sprinkling is allowed to leave a crust about the plants. In watering, the earth should be thoroughly wet, so that the moisture will get to the lower and outer roots of the plants. In order to check evaporation after sprinkling, the surface should be broken as soon as dry enough to work. The watering should be repeated when it is evident, upon careful watching, that more moisture is necessary. It must be remembered that the small, active roots, which take up moisture and plant food, are most numerous at the extremities of the large roots and at a distance from the stem. The water must be so given as to reach these small roots.

The best time for watering is generally thought to be at evening, but Bellair says: "In the spring, in the middle of the day, because the morning and evening are too cool; in the summer, at evening because the days are so hot that a great part of the water given during the day would be evaporated immediately; in autumn, in the morning, because the nights are cold."

Mr. Saunders says: "Water at any time when the plants need it, and water thoroughly. When I am told that watering in the sunshine at noon will burn up my plants, I answer that the plants will certainly burn up if I do not water them."

KILLING THE WEEDS.

Weeds will be most troublesome when rain is plentiful. The plow and hoe ought to be depended upon mainly. Hand weeding is necessary in some cases, but is always slow and tiresome. Various forms of cultivators and wheel hoes are in use and have many advantages over the ordinary field implements. Also, there are several forms of hand hoes made to cut just below the surface and kill the weeds more effectually and rapidly than the ordinary hoes will do.

Several kinds of grasses are the hardest to deal with when once they get set in the ground. The worst of these are witch grass, or couch grass, and Johnson grass. Sometimes very troublesome but less important are crab grass, Nimble Will, and Bermuda grass. The thing to do with these is to see that they are well killed out before the garden is planted and not to allow them a start afterwards.

INSECTICIDES.

Various forms of insecticides are used to kill cabbage worms, potato bugs, and the like. Farmers' Bulletin No. 19 gives directions as to the preparation of many of these. Hand picking of worms and brushing bugs off the plants into baskets are primitive means of protection, but sometimes prove the most practicable and most effective. A flock of turkeys often proves to be of great assistance against insects.

SPECIFIC DIRECTIONS FOR SEVERAL VEGETABLES.

Artichoke.—The Jerusalem artichoke (fig. 6) in a deep, favorable loam, well prepared, will produce at the rate of 300 to 600 bushels to the acre.

Two or three tubers, if small, are planted in a hill. The hills are 3 feet apart each way. Cultivation is necessary if good results are desired, but the plant will produce without any care whatever. The tubers are ready for use early in October and may be dug at any time when the ground is not frozen until late in March. Freezing does not affect them and they come to the table fresh from the earth in the early spring when other vegetables are likely to be stale and musty. They are boiled or steamed till soft and served with cream sauce; they are also used as salads or pickles. They have about the same food value as potatoes. A pint of tubers, cut to eyes as potatoes are, will plant 25 to 30 hills.

Asparagus.—This vegetable is one of the earliest to be ready for use. A fertile soil is best, but any good ground thoroughly prepared does well. Fine sandy soil makes the plants gritty. Sow early, in rows 3 feet apart; cover rather lightly Thin when 3 or 4 inches nigh to 1 foot in the row if the soil is strong; farther apart on a sandy soil. Cultivate carefully, and supply a good dressing of well-rotted manure each spring. The plant should grow vigorously. It will be ready for use in the third year, and should be cut until late in June. It should then be well worked and left to grow

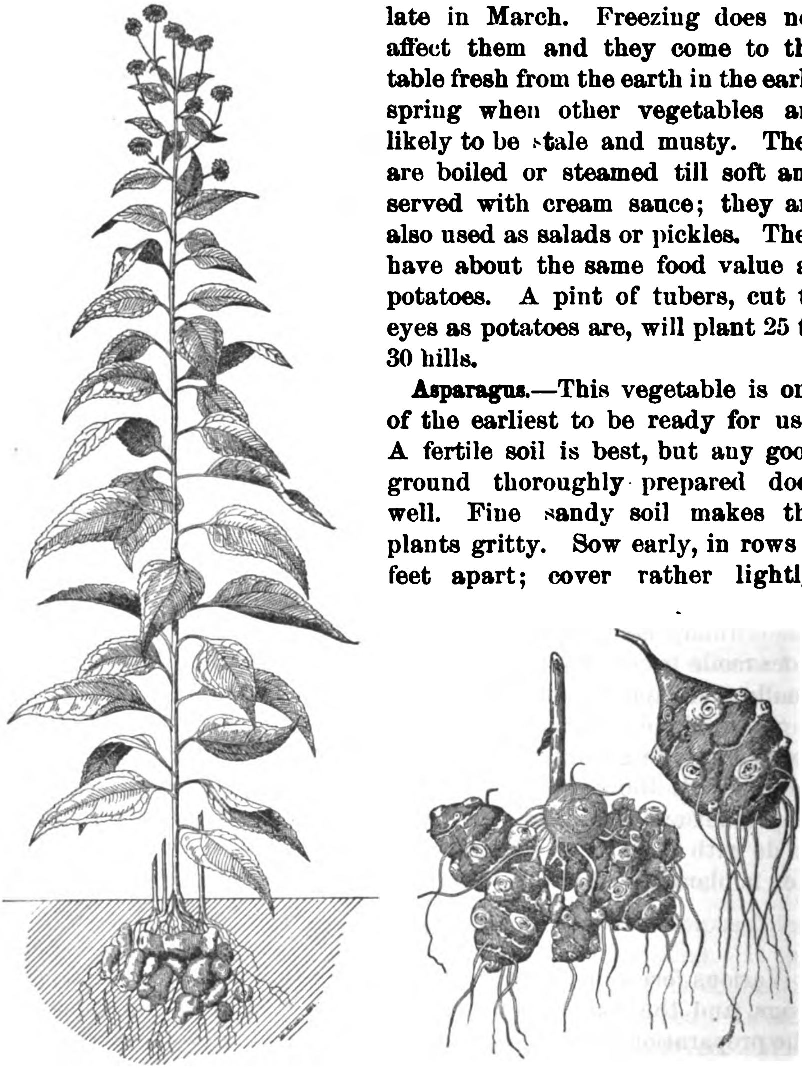

Fig. 6.—Jerusalem artichoke, whole plant and tubers.

to gather strength for the next year's crop of shoots. When the tops begin to die they should be cut and burned. The asparagus on the market is usually white, except a small tip, and the white portion is stringy and inedible. This is the result of deep setting and cutting. If the seed is planted as here directed and the shoots cut a little below the surface when 2 to 3 inches high, a dish considered by many persons to be more satisfactory will be obtained. Two and one-half ounces of seed will sow 100 feet of row. A year may be gained by purchasing the young plants a year old and setting them out 4 inches deep. For details on asparagus growing see Farmers' Bulletin No. 61.

Beans.—A light, loose soil, fertile and well prepared, will give the best results for snap beans, and the crop will be the earlier for a considerable per cent of sand; but a fair return may be expected from almost any soil with ordinary care. Sow as early as frost will permit in drills 3½ feet apart and cover 1 to 2 inches deep. The plants should stand 5 to 7 inches apart in the row. The tillage should be with a horse cultivator. If the space is small the rows may be 8 to 12 inches apart. The plants should not then be quite so close in the row, the supply of fertilizer and water a little more generous, and a wheel hoe should be used in cultivation.

Beans will be ready for the table in six to eight weeks from planting. If wanted very early they can be handled successfully from the hotbed. All green pods should be picked as soon as seed begin to form. By a judicious selection of kinds a succession can be secured without delaying the planting. One quart sows 100 feet of drill.

Lima beans are planted in drills 3 feet apart and allowed to stand 20 inches apart in the row. The beans should be placed with the eye down and covered 2 inches deep. Pole beans, both snap and lima, must be planted later than the dwarf varieties, as they are more easily injured by frost. Three or four plants should be left in each hill. One pint sows 100 hills. Ready for use, lima in 90 days, pole in 110 days.

Beets.—Loose, rich soil with considerable sand is desirable, but beets will grow well in any except a hard, heavy clay. The seed should be planted about an inch deep in drills 3½ feet apart. The sowing may be quite early, as the plants will stand a light frost. When growth has fairly begun thin to 6 or 8 inches in the row. The plants removed may be used as greens. Turnip or globe-shaped are liked best for summer use; the long varieties for winter keeping. Leaf blight is occasionally troublesome in beets and may be met by spraying with Bordeaux mixture.[1]

Winter beets are sown in July and August, and after frost are taken up, the tops cut off, and the roots stored in the cellar. One ounce of seed will sow 60 to 70 feet of drill. Early varieties may be used in 50 to 60 days; the roots will be mature in 150 days.

Cabbage.—The best soil is a deep, rich loam, well worked. Positions shaded during part of the day are to be avoided, for cabbages require abundant light and warmth. A liberal amount of stable manure or other proper fertilizer will make good returns.

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[1] See Farmers' Bulletin 19. Some Important Insecticides, p. 7.

The young plants should be started early in a hotbed and transplanted. Usually they must be kept for a time in the cold frame before being finally set in hills 3 feet apart. It is best to wait for a rain before setting out, but shallow drills may be made and soaked with water over night. A light mulch should be applied to the plants when set. In dry, hot weather water should be given liberally and the plants shaded carefully with boards or leaves.

Cabbages have several enemies, which will destroy the crop if left alone. Among these are root maggots, against which slips of tarred paper have been used successfully; cabbage worms, which may be destroyed with pyrethrum or kerosene emulsion, and club root, for which there is no known remedy.

One ounce of seed will produce 1,500 to 3,000 plants. Ready for use in 100 to 160 days.

Carrots.—Sow early in loose, rich soil in rows 3 feet apart for horse cultivator or 1 foot for the hoe. The seed is small and slow to start. It should be covered lightly and pressed down firmly. If radish seed be sown in the same row they will break the surface and mark the rows so that relief may be given if the ground should bake. Thin to 4 inches apart in the row. Carrots are considered best when young and tender, and successive sowings will be necessary to supply them in that condition. One ounce will plant 150 feet of row. Carrots may be used in 70 to 120 days, varying with variety, management, etc.

Cauliflower.—This vegetable deserves more general cultivation in the farm garden. It can be raised with about the same soil, planting, and care as cabbage, but the supply of moisture must be maintained more carefully. The plants do not stand very hot weather. When the plants begin to head the loose leaves should be bent over to whiten the center. One ounce of seed will give 1,000 to 2,000 plants.

Celery.—Unusual care is necessary to grow celery, but it seldom fails to respond to proper treatment. Light, rich, and very fine soil is needed to plant the seed in, and a rich, peaty loam, "a sandy muck or mold, or any loam that is abundantly supplied with humus", is right for growing the celery to maturity.

Young plants may be bought, but it will frequently prove cheaper to grow them from the seed and they will then be stronger and thriftier. The seed should be sown early in the house or in a good hotbed. They require a very little covering of fine earth and some growers merely press them into the soil. A small box will give room for starting an abundance of plants. When the second leaves appear they should be transplanted 1½ to 2 inches apart in large boxes, and as they begin to grow should be hardened by exposure to the open air and sun in the warm part of the day. When settled warm weather has come, May or

June, and the plants have made a growth of 5 or 6 inches, they should be set in the garden. It will be of advantage at this time to trim off the tops of the leaves and about one-fifth at the end of the main root. The ground must be thoroughly worked and fertilized with fine, rich compost, containing chicken manure if practicable. The plants are set in rows 3 to 4 feet apart and 5 to 6 inches apart in the row. It is practically impossible to make the ground too rich, and good stable manure seems to be most in favor for the purpose. As much as 2,000 pounds to the acre of a "high grade complete commercial fertilizer" may be used upon the soil already supplied with stable manure. The soil must be kept moist, and if it is not naturally so water must be turned on liberally. The soil must be loose both before and after transplanting and weeds kept down industriously. Cultivation must be especially careful until the celery has made a good start after the final transplanting.

Celery may be grown successfully by sowing the seed as directed, from April 1 to 15 in the central portions of the United States. A light mulch of fine hay or light litter over the seed will help bring it up. The young plants should appear in about two weeks. Then the mulch must be carefully removed.

When the plants are nearly grown they must be blanched. This is done usually by earthing up the stems gradually till only the tips of the leaves remain out. Great care must be exercised to keep the dirt out of the center. A method of blanching much in favor with progressive growers is by setting boards on each side of the row so as to shade it completely. This is especially successful with the so-called self-blanching kinds. Blanching by setting the plants very close and depending upon the stalks shading each other has not proved very successful so far. One ounce of seed will sow 100 feet of drill. Ready for use in 140 to 175 days.

Cucumbers.—A warm, light sandy soil well supplied with humus is recommended, while a hard, cold clay and any poor soil are unsuitable. Hills a foot deep and 4 to 5 feet wide should be prepared by thoroughly pulverizing the ground and mixing into it a liberal supply of stable manure and fertilizer. The only thing to be guarded against in fertilizing is the production of an excess of vine, with corresponding lack of fruit. This condition calls for pinching off the terminal buds. The hills should be 6 to 8 feet apart. Seed should be planted germ end down an inch and a half deep late in April. Weeds must be kept down carefully while the plants are young. When the vines cover the ground it is difficult to do anything with the weeds, because every movement is likely to injure the cucumbers. Many successful growers use trellises or frames.

It is best to start the cucumbers in the hotbed or in the house early in March. Sow on upturned pieces of sod 6 inches square and cover with an inch of light, rich soil. Transfer to the open ground early in May. Successional sowing should begin about the middle of May.

One to two ounces of seed will plant 100 hills. Ready for use in 50 to 75 days.

Ground cherry.—This plant (fig. 7), also known as strawberry or winter cherry, grows wild in the cornfields of the Mississippi Valley. Its fruit is used for preserves for the table. A good soil well worked improves the quantity and quality of its production. It may be planted early in drills 3 feet apart, with 12 to 18 inches between the plants in the drill. It is recommended as very productive and as keeping through the winter in the husk.

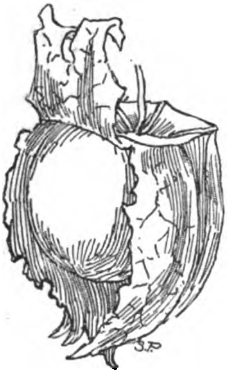

Fig. 7.—Ground Cherry.

Lettuce.—This plant is the most generally used in this country for salads. A warm mellow soil is required, with plenty of water and thorough weeding. Sow as soon as danger of severe frost is past. The seeds are very small and may be mixed with sand for sowing. They should be covered very lightly. In the Southern States it is usual to sow the seed broadcast and cover by drawing the fingers lightly through the soil, or to rake in with a light branch of a tree. The ordinary rake will cover too deeply. One kind, the cabbage lettuces, form heads naturally; the other, the Cos lettuces, do not head, but may be blanched by tying up the leaves. Lettuce may be used in 3 to 4 weeks from planting. One-quarter of an ounce of seed will sow 100 feet of drill.

Martynia (fig. 8).—A rich, warm soil is needed. Plant when frost is gone for the year in hills 3 feet apart each way. The seed is slow to come up. One good plant to the hill is enough. The seed pods will be ready for pickling in 60 to 80 days and are put up in the same way as cucumbers. Half an ounce of seed will plant 100 hills.

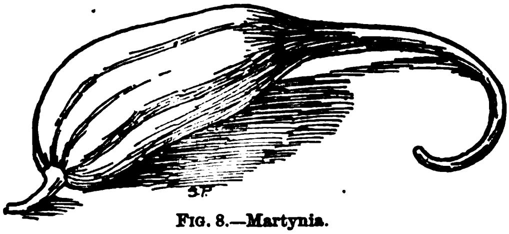

Fig. 8.—Martynia.

Melons.—Both muskmelons (cantaloupes) and watermelons need a warm, rich soil; but care must be observed not to grow the vines at the expense of fruit by improper use of fertilizing materials. Melons grow readily in a fertile sandy loam. The management is about the same as for the cucumber, but more light, heat, and air are needed and not so much moisture. The vines may be pinched back if they tend to run excessively. Muskmelons need 2 ounces of seed to the 100 hills; watermelon, 4 ounces. Muskmelons ripen in about 100 days from sowing the seed, watermelons in 120 to 140 days.

Okra.—A deep, rich soil well prepared is to be desired for okra, but it makes a thrifty growth and will do well with very little care after it has a good start, unless the season is very wet and cool. The seed does not come up with much certainty, and two or three plantings may be necessary. Seed should usually be procured fresh from a dealer every year, but with intelligent handling it may be saved from the pod. Okra should be planted as soon as frost is gone, in drills 2½ to 3 feet apart and covered an inch deep. Thin to 12 or 18 inches as soon as the plants begin to grow well.

The pods are cut 3 to 5 days after the flowers fall, and are usually boiled alone or in soup with other vegetables. One and a half ounces of seed will plant 100 hills. Use of the pods may begin in 90 to 100 days from planting.

Onions.—A rich, deep, friable loam is the best soil. Sow early in shallow drills 1 to 3 feet apart, and cover with half an inch of well pulverized soil. Thin to 4 inches in the row. Keep down the weeds industriously. This will usually require working every ten days. Instead of sowing seed, the sets may be put out 4 to 6 inches apart in rows a foot apart. The ground does not then need to be so finely pulverized before planting. If the sets are put out in October they will furnish slender white stems for the table about two weeks from the beginning of growth in the spring. Onions well ripened keep well through the winter in a dry, cool place. One-third ounce of seed or 1 quart of sets go to 100 feet of row. Farmers' Bulletin No. 39 furnishes full details on onion culture. Ready for use in 100 to 110 days; ripe in 160 days, according to variety.

Parsley.—This is a biennial. Deep rich soil made very fine and mellow is best. Sow early in the spring in drills half an inch deep and a foot apart. Thin to 6 inches in the row, when the second pair of leaves appear. If wanted in early spring parsley may be sowed in September in a moderately fertile soil. During the cold weather the plants should be covered nearly to the top with leaves, held in place by brush. One-fourth of an ounce of seed will sow 100 feet of drill.

Parsnips.—This vegetable is grown precisely as the carrot (p. 18). It may be left in the ground all winter and dug as wanted. It is considered sweeter and better when managed in that way. One-fourth of an ounce of seed will sow 100 feet of drill. The roots are ready for use in 140 days from planting.

Peas.—Frost is not so fatal to peas as to beans, and the sowing may therefore be earlier. The soil, planting, and cultivation are practically the same as for beans (p. 17), but peas require a better soil and more attention. Some of the best peas grow tall and require sticks or wire to hold them off the ground. The half dwarf kind may be planted in close rows so that they will support each other. The seed does not come up with quite so much certainty as beans and the plant seems to suffer more by accidents and disease. Mildew is probably the worst enemy, and is treated with Bordeaux mixture. (Footnote p. 17.) Weevil in the seed may be killed by soaking for an hour in a solution of an ounce of copper carbonate and a little less than a pint of ammonia to 1½ gallons of water. If peas are wanted for several weeks, successive sowings must be made or varieties judiciously chosen.

Two distinct kinds of peas are known, smooth seeded and wrinkled seeded. The latter are earlier and last longer; the former sometimes have edible pods and are known as sugar peas. One pint of seed will plant 100 feet of drill. Ready for use in 50 to 90 days, according to variety.

Potatoes.—A rich, sandy loam is the most favorable soil. It should be thoroughly loosened so that the tubers may grow freely. Plant as soon as frosts cease, about 3 inches deep, 12 to 18 inches apart, in rows 3 feet apart. The tubers are cut for planting so as to leave one or two eyes to each piece. Level cultivation is preferred. The weeds must be kept down, and when the potato bugs appear they must be killed promptly by a free use of Paris green or by brushing off by hand. A second planting, covered deeper, about May day will give potatoes for use in August, and a still later planting will furnish the fall crop. In digging and storing potatoes should not be much exposed to light. A peck of potatoes will plant 300 feet of row. For additional information regarding potatoes see Farmers' Bulletin, No. 35. Potatoes are ready for use in 85 to 135 days.

Radishes.—Among the first usually sown are radishes. They require little space and can be grown indoors. A loose, rich, deep soil, better if sandy, is required. The radish should grow very rapidly and be eaten while still very young. The drills are made 12 to 14 inches apart and the plants 3 inches in the drill. The seed should be covered about an inch deep. It comes up well, but should be planted thick and thinned promptly. Radishes are frequently sown broadcast and raked in lightly. Grubs sometimes destroy the roots. The only escape is to plant in soil where the grubs have not found lodgment. Frequent sowings will be made by those who enjoy fresh, crisp radishes. An ounce of seed will sow 100 feet of drill. Ready for use in 20 to 45 days, according to kind.

Rhubarb.—The soil should be deeply worked and rich, but the plant will grow with ordinary care upon any good ground. An open position, sheltered from east winds, is desirable. Bone meal and barnyard manure are recommended as fertilizers. Rhubarb may be grown by sowing the seed in the spring, but it is better to use the divided roots of old plants. They should be set 2 to 3 feet apart and may occupy an otherwise unused corner. Once set, it will produce for several years with very little attention. Use begins in the second season and must be discontinued in the summer in time to allow the plants to recuperate for the next year. An ounce of seed will sow 125 feet of drill.

Salsify.—The planting and cultivation are the same as for the carrots (p. 18), except that a little more space between the plants in the drill will be an advantage. Salsify may be left out all winter if freezing is not very severe, but it is considered better to pull and store.

One ounce of seed will sow 100 feet of drill. Ready for use in 130 to 140 days.

Spinach.—For early use sow in a sheltered place in a dry, well prepared, fertile soil. Later the plants seem to need moister ground. If sown in the fall, spinach can usually be wintered under a mulch, which should be removed early in the spring. The drills should be a foot apart and the seed covered about an inch deep. Thin to 6 inches apart, and finally, as the plants grow, to 12 inches in the row. Gather two or three of the largest leaves as wanted from each plant as soon as they are large enough. Cut the heads when flower stems appear. New Zealand spinach is a new variety quite different from the common. The plants should stand 3 feet apart. Perpetual spinach is sown in rows a foot apart in very rich soil and thinned so as to give plenty of room. Half an ounce of seed is right for 100 feet of drill of the ordinary kind; 25 plants of the New Zealand is enough for a family. Ready for use in 25 to 35 days; New Zealand, 40 to 55 days.

Squash.—A warm, light, rich soil, deeply worked, is best. Plenty of stable manure will be repaid by increased yield. Plant summer varieties in slightly elevated hills, 4 feet apart each way, as soon as the ground is warm. Place the seed upright, with the eye down, and cover 1 to 3 inches deep. Late varieties should be planted in hills 6 to 8 feet each way, leaving four plants to a hill. Another way is to plant in rows 12 to 20 feet apart and thin to 6 feet between hills in the row. Early beans or peas may be cultivated between the rows, to be cleared away in July. Weeds must be kept down and moisture held by cultivation. The hand hoe must be used after the vines begin to run. Seed from the home garden is likely to be crossed with cucumbers or melons and the product unsatisfactory. One ounce of seed for summer and two ounces for winter will plant 25 hills. The summer squash may be used in 50 days; winter squash will be ripe in 115 to 125 days.

Sweet corn.—This crop requires much room and a rich soil, broken deep. It does not demand the careful pulverizing and loosening of the ground before planting which is usual in garden culture but will give better results for this and other generous treatment. Plant as soon as danger of frost is past in drills 3½ feet apart, dropping three or four grains every 18 inches, or in hills 3½ feet each way. Cover 2 to 4 inches deep. Keep the surface of the earth broken, so as to insure plenty of moisture and kill the weeds. For the garden the early sweet varieties are most useful. They will come to the table several weeks earlier than the large field kinds. Successional planting should be made, and about an eighth of an acre should give a constant supply of roasting ears for an ordinary family. One-fourth to one-half pint will plant 100 feet of drill. Corn should be ready for use in 55 to 85 days.

Sweet potato.—Warm, sandy, rather dry soil should be selected if available. Plants may be bought. If raised in the hotbed the old potatoes should be buried 2 or 3 inches deep in the bed two or three weeks before the plants are wanted. When frost is gone set the young plants in well-manured rows 5 feet apart and 12 to 18 inches in the row. Shallow cultivation is to be given, killing the weeds and keeping the soil loose. When the vines begin to run they must be laid aside before plowing. In some localities the crop is much injured if the vines take root in running, and this is prevented by moving them after other attention has ceased. Two to four plowings with the cultivator and one or two hoeings will be enough. They will be ready for use late in August, when a little more than half grown. They are taken from the hills as wanted without pulling up the vines. The potatoes are all dug when frost kills the vines. Five hundred plants will set from 350 to 500 feet of row. Additional information is given in Farmers' Bulletin No. 26.

Tomato.—A clayey soil is liked by some, sandy by others. Deep preparation and plenty of manure will make good tomatoes on almost any soil. Too much manure on a light soil may cause the plant to run to vine. Sow the seed in the hotbeds about the end of March, and set the plants when 2 inches high 3 feet apart in rows 3½ feet apart. They should not be set out till the temperature is likely to stay above 60°. This will usually be when oak leaves are well out of the bud.

Thorough cultivation, loosening the soil and killing the weeds, is necessary till the plants begin to spread and cover the ground. The soil should be drawn up to the plants in hills 2 or 3 inches high. Some support, as a trellis, is necessary to keep the fruit off the ground.

The fruit will begin to ripen in August, and should be picked as fast as ripe. The plant will usually continue bearing till frost, and if the full-sized green tomatoes are then placed under a cold frame or on the cellar floor they will usually ripen. One ounce of seed will produce 3,500 to 4,500 plants. Farmers' Bulletin No. 76, Tomato Growing, gives full details.

Turnips.—Rich finely pulverized soil is needed. A sandy or gravelly loam is preferred. The seed may be sown quite early, as the plants are not easily hurt by frost. Sow in drills 1 foot apart and half an inch deep, or sow broadcast and rake in lightly. If there should be no rain a thorough sprinkling will insure germination. The plants should stand at least 3 inches apart. Repeated sowings are necessary for a satisfactory succession in summer. White varieties are preferred for summer use.

For winter, sow late in July. A yellow kind is much liked. No cultivation is required when sown broadcast. Turnips may be stored the same as potatoes. The tops should be cut away. If covered with sand they will not wither, but may start to grow if the cellar is warm and will become pithy. Turnips mature in about two months. One ounce of seed is enough for 200 feet of drill.

U. S. DEPARTMENT OF AGRICULTURE.

FARMERS' BULLETIN No. 95.

GOOD ROADS FOR FARMERS.

BY

MAURICE O. ELDRIDGE,
Acting Director, Office of Public Road Inquiries.

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LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Office of Public Road Inquiries,
Washington, D. C., February 6, 1900.

Sir: I have the honor to transmit herewith revised copy of Farmers' Bulletin No. 95, Good Roads for Farmers, and to recommend a reprint of the same to meet the constant demand for the information it contains. The manuscript of the bulletin was originally submitted March 23, 1899, by Gen. Roy Stone, then Director of the Office of Public Road Inquiries. Since its publication some slight inaccuracies have been discovered which have been corrected in the present edition. The end in view is to present in the plainest possible language the fundamental principles of road building and maintenance, and to furnish instruction and advice to those whose facilities are limited and who are often supplied with only natural materials.

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Respectfully,

Maurice O. Eldridge,
Acting Director.

Hon. James Wilson,
Secretary of Agriculture.

CONTENTS.

Page.
Introduction 7
Principles which should govern location and treatment of roads 8
  Grades 11
  Drainage 12
    Surface drainage 14
  Water breaks 15
  Side ditches 16
  Subdrainage 17
Different kinds of roads 18
  Earth roads 19
    Drainage 20
    Rolling 20
    Construction 20
    Filling the ruts 22
    Repairs by road machines 23
    Use of wide tires 24
    Time to repair roads 24
  Sand roads 25
  Roads of sawdust, tanbark, etc 25
  Corduroy roads 25
  Hard roads 26
  Gravel roads 28
    Seaside and river gravel 28
    Blue gravel and bank gravel 28
    Gravel on earth roads 29
    Grade and width of gravel roads 29
    Rolling the road 29
    Maintenance 30
  Shell roads 31
  Stone roads 31
    Useful stones for road building 32
    Stone crushers 34
    Screening the stone 35
    The macadam and telford methods 37
    Macadam construction 37
      Application of the material 38
    Rollers 41
    Binding material 41
    Telford construction 41
    Stone road maintenance 42
Trees alongside of roads 44
Cost of roads 45
Conclusion 46

ILLUSTRATIONS.

Page.
FIG. 1. Grand view of the Axenstrasse as it skirts the bay of Uri near Fluelen, Switzerland 8
2. Macadam road in Italy 10
3. Hauling hay to market over a level road in Normandy 11
4. Surplus water lying in country road after heavy shower 13
5. Scene in country town in the spring of 1892 14
6. Cross sections of two good forms for earth roads 15
7. Roadside ditch dug by erosion 16
8. Proper form of surface ditch 16
9. Miles's drainage scoop for preparing bottom of ditch for tile 18
10. Instrument for grading subdrain ditch to receive tile 18
11. Harris's grade level for establishing road and drain grades 18
12. Subdrain constructed with tile and stone 19
13. Subdrain made with field stones 19
14. Subdrain constructed of logs and fagots of wood 19
15. Subdrain of brush for conveying spring water along or under road 19
16. Subdrain of stone for conveying spring water along or under road 19
17. Subdrain of bricks for conveying spring water along or under road 19
18. Cross section of 14-foot road, showing result of improper construction 20
19. Section of unrolled earth road 20
20. Section of compact, smooth earth road made solid by roller 20
21. Russell steam road roller, combination 21
22. Champion road machine at work on earth road 22
23. Champion road machine preparing earth road 23
24. Champion reversible road roller for horse power 24
25. The "Richardson" adjustable wide tire 24
26. The "Richardson" adjustable tire in place on wheel of farm wagon 24
27. Loads on macadamized road in Mecklenburg County, N. C 27
28. The Austin reversible horse roller, changeable weight 30
29. Iroquois steam road roller 30
30. Road in France between Fontainebleau and Sens 31
31. Complete crushing plant in operation at Towanda, Pa 33
32. Stationary crushing plant 34
33. Semistationary crushing plant 34
34. Portable crushing plant 35
35. Stationary Champion rock crusher with separating apparatus 35
36. Champion distributing cart in operation 36
37. John L. Macadam 36
38. Cross section of macadam road 37
39. Buffalo Pitts steam road roller 37
40. Cross section of macadam road, faulty construction 38
41. Bad condition of road, faulty macadam construction 38
42. Excavating and preparing roadbed for macadam surface 39
43. First course of stone on macadam road ready for rolling 39
44. First course of stone on macadam road partially rolled 40
45. Stone on macadam road firmly packed by rolling 40
46. The Addison reversible horse roller, changeable weight 41
47. Transverse section of telford road with macadam surface 42
48. Steam roller with spikes in wheel breaking up road surface 43
49. Hauling 9 tons of stone on wide-tired wagon 44

GOOD ROADS FOR FARMERS.

INTRODUCTION.

Bad roads constitute the greatest drawback to rural life, and for the lack of good roads the farmers suffer more than any other class. It is obviously unnecessary, therefore, to discuss here the benefits to be derived by them from improved roads. Suffice it to say, that those localities where good roads have been built are becoming richer, more prosperous, and more thickly settled, while those which do not possess these advantages in transportation are either at a standstill or are becoming poorer and more sparsely settled. If these conditions continue, fruitful farms may be abandoned and rich lands go to waste. Life on a farm often becomes, as a result of "bottomless roads," isolated and barren of social enjoyments and pleasures, and country people in some communities suffer such great disadvantage that ambition is checked, energy weakened, and industry paralyzed.

Good roads, like good streets, make habitation along them most desirable; they economize time and force in transportation of products, reduce wear and tear on horses, harness, and vehicles, and enhance the market value of real estate. They raise the value of farm lands and farm products and tend to beautify the country through which they pass; they facilitate rural mail delivery and are a potent aid to education, religion, and sociability. Charles Sumner once said, "The road and the schoolmaster are the two most important agents in advancing civilization."

The difference between good and bad roads is often equivalent to the difference between profit and loss. Good roads have a money value to farmers as well as a political and social value, and leaving out convenience, comfort, social and refined influences which good roads always enhance, and looking at them only from the "almighty dollar" side, they are found to pay handsome dividends each year.

People generally are beginning to realize that road building is a public matter, and that the best interests of American agriculture and the American people as a whole demand the construction of good roads, and that money wisely expended for this purpose is sure to return.

PRINCIPLES WHICH SHOULD GOVERN LOCATION AND TREATMENT OF ROADS.

Road making is perfected by practice, experience, and labor. Soils and clays, sand and ores, gravels and rocks, are transformed into beautiful roads, streets, and boulevards, by methods which conform with their great varieties of characters and with nature's laws. The art of road building depends largely for its success upon its being carried on in conformity with certain general principles.

It is necessary that roads should be hard, smooth, comparatively level, and fit for use at all seasons of the year; that they should be properly located, or laid out on the ground, so that their grades may be such that animate or inanimate power may be applied upon them to the best advantage and without great loss of energy; that they should be properly constructed, the ground well drained, the roadbed graded, shaped, and rolled, and that they should be surfaced with the best material procurable; that they should be properly maintained or kept constantly in good repair.

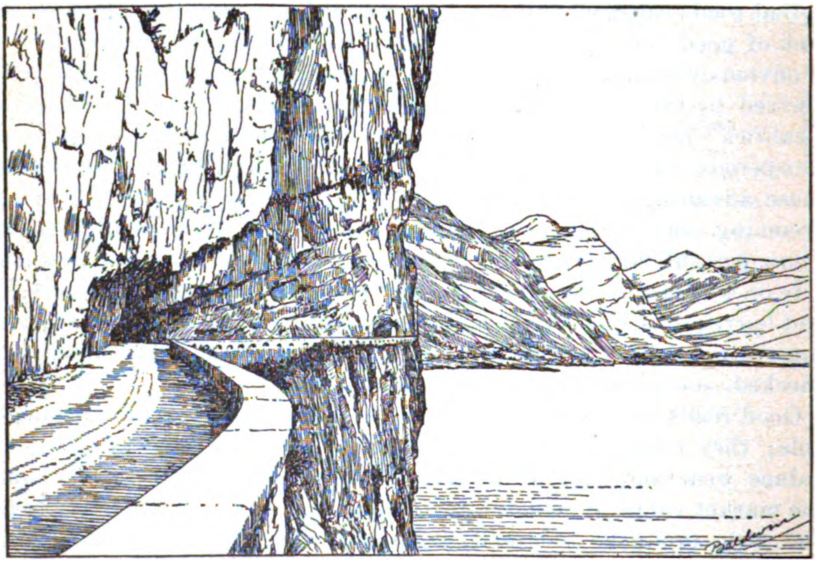

FIG. 1.—Grand view of the Axenstrasse as it skirts the bay of Uri near Fluelen in the Alps of Switzerland.

All the important roads in the United States can be and doubtless will be macadamized or otherwise improved in the not distant future. This expectation should govern their present location and treatment everywhere. Unless changes are made in the location of the roads in many parts of the country it would be worse than folly to macadamize them. "Any costly resurfacing of the existing roads will fasten them where they are for generations," says General Stone. The chief difficulty in this country is not with the surface, but with the steep grades, many of which are too long to be reduced by cutting and filling on the present lines, and if this could be done it would cost more in many cases than relocating them.

Many of our roads were originally laid out without any attention to general topography, and in most cases followed the settler's path from cabin to cabin, the pig trail, or ran along the boundary lines of the farms regardless of grades or direction. Most of them remain to-day where they were located years ago, and where untold labor, expense, and energy have been wasted in trying to haul over them and in endeavors to improve their deplorable condition.

The great error is made of continuing to follow these primitive paths with our public highways. The right course is to call in an engineer and throw the road around the end or along the side of steep hills (fig. 1) instead of continuing to go over them; or to pull the road up on dry solid ground instead of splashing through the mud and water of the creek or swamp. Far more time and money have been wasted in trying to keep up a single mile of one of these "pig-track" surveys than it would take to build and keep in repair two miles of good road.

Another and perhaps greater error is made by some persons in the West who continue to lay out their roads on "section lines." These sections are all square, with sides running north, south, east, and west. A person wishing to cross the country in any other than these directions must necessarily do so in rectangular zigzags. It also necessitates very often the crossing and recrossing of hills and valleys, which might be avoided if the roads had been constructed on scientific principles.

In the prairie State of Iowa, for example, where roads are no worse than in many other States, there is a greater number of roads having much steeper grades than are found in the mountainous Republic of Switzerland. In Maryland the old stagecoach road or turnpike running from Washington to Baltimore makes almost a "bee line," regardless of hills or valleys, and the grades at places are as steep as 10 or 12 per cent, where by making little detours the road might have been made perfectly level, or by running it up the hills less abruptly the grade might have been reduced to 3 or 4 per cent, as is done in the hilly regions of many parts of this and other countries (fig. 2). Straight roads are the proper kind to have, but in hilly countries their straightness should always be sacrificed to obtain a level surface so as to better accommodate the people who use them.

Graceful and natural curves conforming to the lay of the land add beauty to the landscape, besides enhancing the value of property. Not only do level curved roads add beauty to the landscape and make lands along them more valuable, but the horse is able to utilize his full strength over them (fig. 3); furthermore a horse can pull only four-fifths as much on a grade of 2 feet in 100 feet, and this gradually lessens until with a grade of 10 feet in 100 feet he can draw but one-fourth as much as he can on a level road.

All roads should therefore wind around hills or be cut through instead of running over them, and in many cases the former can be done without greatly increasing the distance. To illustrate, if an apple or pear be cut in half and one of the halves placed on a flat surface, it will be seen that the horizontal distance around from stem to blossom is no greater than the distance over between the same points.

The willfulness of one or two private individuals sometimes becomes a barrier to traffic and commerce. The great drawback to the laying out of roads on the principle referred to is that of the necessity, in some cases, of building them through the best lands, the choicest pastures and orchards, instead, as they do now, of cutting around the farm line or passing through old worn-out fields or over rocky knolls. But if farmers wish people to know that they have good farms, good cattle, sheep, or horses, good grain, fruit, or vegetables, they should let the roads go through the best parts of the farms.

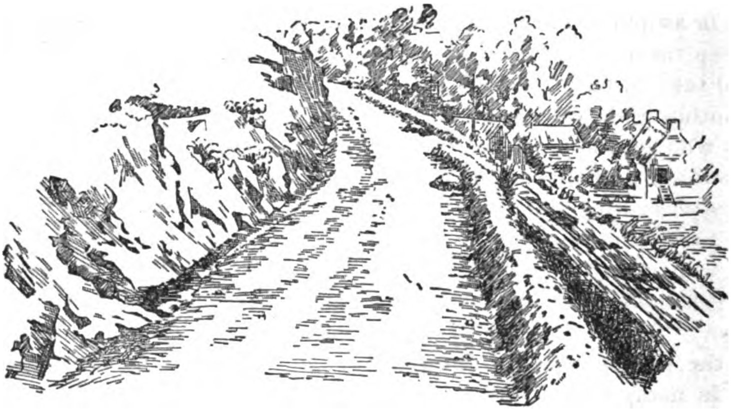

FIG. 2.—Macadam road in Italy showing manner of location and construction of road running around a hill.

The difference in length between a straight road and one which is slightly curved is less than one would imagine. Says Sganzin: "If a road between two places 10 miles apart were made to curve so that the eye could see no farther than a quarter of a mile of it at once, its length would exceed that of a perfectly straight road between the same points by only about 150 yards." Even if the distance around a hill be much greater, it is often more economical to construct it that way than to go over and necessitate the expenditure of large amounts of money in reducing the grade, or a waste of much valuable time and energy in transporting goods that way. Gillespie says "that, as a general rule, the horizontal length of a road may be advantageously increased to avoid an ascent by at least twenty times the perpendicular height which is thus to be avoided—that is, to escape a hill 100 feet high, it would be proper for the road to make such a circuit as would increase its length 2,000 feet." The mathematical axiom that "a straight line is the shortest distance between two points" is not, therefore, the best rule to follow in laying out a road; better is the proverb that "the longest way round is the shortest way home."

GRADES.

The grade is the most important factor to be considered in the location of roads. The smoother the road surface, the less the grade should be.

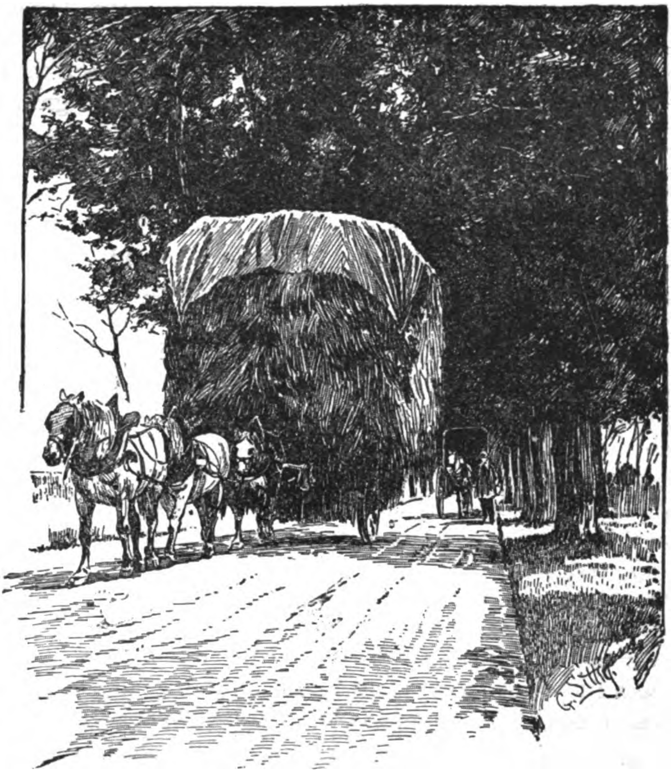

FIG. 3.—Hauling hay to market over a level road in Normandy, France. This load weighs upward of 4 tons. The road is always kept smooth and hard, making the markets always accessible (drawn from photograph).

Whether the road be constructed of earth, stone, or gravel, steep grades should always be avoided if possible. They become covered at times with coatings of ice or slippery soil, making them very difficult to ascend with loaded vehicles as well as dangerous to descend. They allow water to rush down at such a rate as to wash great gaps alongside or to carry the surfacing material away. As the grade increases in steepness either the load has to be diminished in proportion or more horses or power attached. From Gillespie we find that if a horse can pull on a level 1,000 pounds, on a rise of—

1 foot in—	Pounds.
100 feet he draws	900
50 feet	810
44 feet	750
40 feet	720
30 feet	640
25 feet	540
24 feet	500
20 feet	400
10 feet	250

It is therefore seen that when the grades are 1 foot in 44 feet or 120 feet to the mile a horse can draw only three-fourths as much as he can on a level; where the grade is 1 foot in 24 feet, or 220 feet to the mile, he can draw only one-half as much, and on a 10 per cent grade, or 520 feet to the mile, he is able to draw only one-fourth as much as on a level road.

As a chain is no stronger than its weakest link, just so the greatest load which can be hauled over a road is the load which can be hauled through the deepest mud hole or up the steepest hill on that road. The cost of haulage is, therefore, necessarily increased in proportion to the roughness of the surface or steepness of the grade. It costs one and one-half times as much to haul over a road having a 5 per cent grade and three times as much over one having a 10 per cent grade as on a level road. As a perfectly level road can seldom be had, it is well to know the steepest allowable grade. If the hill be one of great length, it is sometimes best to have the lowest part steepest, upon which the horse is capable of exerting his full strength, and to make the slope more gentle toward the summit, to correspond with the continually decreasing strength of the fatigued animal.

So far as descent is concerned, a road should not be so steep that the wagons and carriages can not be drawn down it with perfect ease and safety. Sir Henry Parnell considered that when the grade was no greater than 1 foot in 35 feet vehicles could be drawn down it at a speed of 12 miles an hour with perfect safety. Gillespie says:

> It has been ascertained that a horse can for a short time double his usual exertion; also, that on the best roads he exerts a pressure against his collar of about one thirty-fifth of the load. If he can double his exertion for a time, he can pull one thirty-fifth more, and the slope which would force him to lift that proportion would be, as seen from the above table, one of 1 in 35, or about a 3 per cent grade. On this slope, however, he would be compelled to double his ordinary exertion to draw a full load, and it would therefore be the maximum grade.

DRAINAGE.

Mr. Isaac B. Potter, an eminent authority upon roads, says:

> Dirty water and watery dirt make bad going, and mud is the greatest obstacle to the travel and traffic of the farmer. Mud is a mixture of dirt and water. The dirt

is always to be found in the roadway, and the water, which comes in rain, snow, and frost, softens it; horses and wagons and narrow-wheel tires knead it and mix it, and it soon gets into so bad a condition that a fairly loaded wagon can not be hauled through it.

We can not prevent the coming of this water, and it only remains for us to get rid of it, which can be speedily done if we go about it in the right way. Very few people know how great an amount of water falls upon a country road, and it may surprise some of us to be told that on each mile of an ordinary country highway 3 rods wide within the United States there falls each year an average of 27,000 tons of water. In the ordinary country dirt road the water seems to stick and stay as if there was no other place for it, and this is only because we have never given it a fair opportunity to run out of the dirt and find its level in other places. We can not make a hard road out of soft mud, and no amount of labor and machinery will make a good dirt road that will stay good unless some plan is adopted to get rid of the surplus water. (Fig. 4.) Water is a heavy, limpid fluid, hard to confine and easy to let loose. It is always seeking for a chance to run down a hill; always trying to find its lowest level.

An essential feature of a good road is good drainage and the principles of good drainage remain substantially the same, whether the road be constructed of earth, gravel, shells, stones, or asphalt. The first demand of good drainage is to attend to the shape of road surface. This must be "crowned," or rounded up toward the center, so that there may be a fall from the center to the sides, thus compelling the water to flow rapidly from the surface into the gutters which should be constructed on one or both sides, and from there in turn be discharged into larger and more open channels. Furthermore, it is necessary that no water be allowed to flow across a roadway; culverts, tile, stone, or box drains should be provided for that purpose.

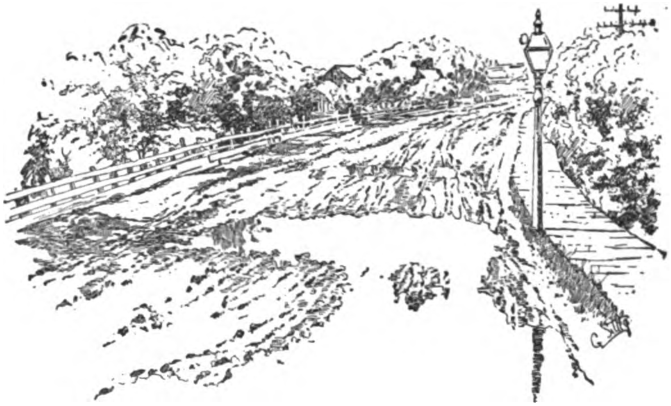

FIG. 4.- Surplus water lying in country road after a heavy shower, indicating lack of proper methods of drainage (drawn from photograph).

In addition to being well covered and drained, the surface should be kept as smooth as possible, that is, free from ruts, wheel tracks, holes, or hollows. If any of these exist, instead of being thrown to the side the water is held back and is either evaporated by the sun or absorbed by the material of which the road is constructed. In the latter case the material loses its solidity, softens and yields to the impact of the horses' feet and the wheels of vehicles, and, like the water poured upon a grindstone, so the water poured on a road surface which is not properly drained assists the grinding action of the wheels in rutting or completely destroying the surface. When water is allowed to stand on a road the holes and ruts rapidly increase in number and size; wagon after wagon sinks deeper and deeper, until the road finally becomes utterly bad (fig. 5), and sometimes impassable, as frequently found in many parts of the country during the winter season.

Road drainage is just as essential to a good road as farm drainage is to a good farm. In fact, the two go hand in hand, and the better the one the better the other, and vice versa. There are thousands of miles of public roads in the United States which are practically impassable during some portion of the year on account of bad drainage, while for the same reason thousands of acres of the richest meadow and swamp lands lie idle from year in to year out.

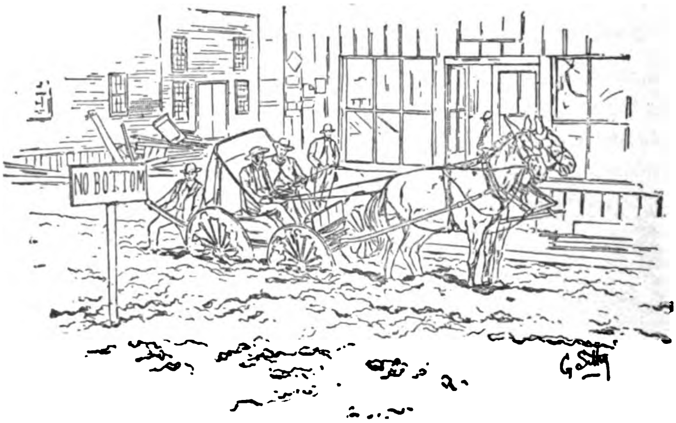

FIG. 5.—Scene in country town in the Spring of 1892 (drawn from photograph,

Surface Drainage.—The wearing surface of a road must be in effect a roof; that is, the section in the middle should be the highest part and the traveled roadway should be made as impervious to water as possible, so that it will flow freely and quickly into the gutters or ditches alongside (fig. 6). The best shape for the cross section of a road has been found to be either a flat ellipse or one made up of two plane surfaces sloping uniformly from the middle to the sides and joined in the center by a small, circular curve. Either of these sections may be used, provided it is not too flat in the middle for good drainage or too steep at the gutters for safety. The steepness of the slope from the center to the sides should depend upon the nature of the surface, being greater or less according to its roughness or smoothness. This slope ought to be greatest on earth roads, perhaps as much in some cases as 1 foot in

20 feet after the surface has been thoroughly rolled or compacted by traffic. This varies from about 1 in 20 to 1 in 30 on a macadam road to 1 in 40 or 1 in 60 on the various classes of pavements and for asphalt sometimes as low as 1 in 80.

Where the road is constructed on a grade or hill the slope from the center to the sides should be slightly steeper than that on the level road. The best cross section for roads on grades is the one made up from two plane surfaces sloping uniformly from the center to the sides. This is done so as to avoid the danger of overturning near the side ditches, which would necessarily be increased if the elliptical form were used. The slope from the center to the sides must be steep enough to lead the water into the side ditches instead of allowing it to run down the middle of the road. Every wheel track on an inclined roadway becomes a channel for carrying down the water, and unless the curvature is sufficient these tracks are quickly deepened into water courses which cut into and sometimes destroy the best improved road.

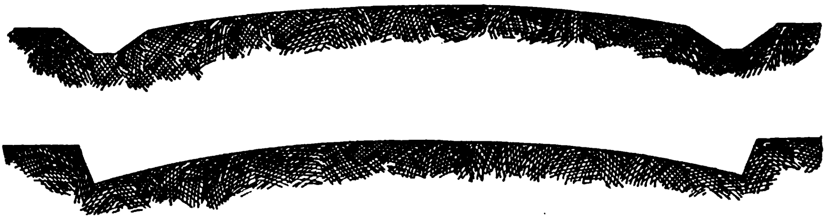

FIG. 6.—Cross sections of two good forms for earth roads. The lower section can be made with a road machine and both sections can be rolled and constructed so that water will run off easily and quickly.

WATER BREAKS.

In order to prevent the washing out of earth roads on hills it sometimes becomes necessary to construct water breaks; that is, broad shallow ditches arranged so as to catch the surface water and carry it each way into the side ditches. Such ditches retard traffic to a certain extent, and often result in overturning vehicles; consequently they should never be used until all other means have failed to cause the water to flow into the side channels; neither should they be allowed to cross the entire width of the road diagonally, but should be constructed in the shape of the letter V. This arrangement permits teams following the middle of the road to cross the ditch squarely and thus avoid the danger of overturning. These ditches should not be deeper than are absolutely necessary to throw the water off the surface, and the part in the center should be the shallowest.

Unfortunately farmers and road masters have a fixed idea that the one way to prevent hills, long and short, from washing is to heap upon them quantities of those original tumular obstructions known indifferently as "thank-you-ma'ams," "breaks," or "hummocks," and the number they can squeeze in upon a single hill is positively astonishing.

SIDE DITCHES.

Quoting Mr. Isaac B. Potter—

> Side ditches are necessary because the thousands of tons of water which fall upon every mile of country road each year, in the form of rain or snow, should be carried away to some neighboring creek or other water channel as fast as the rain falls and the snow melts, so as to prevent its forming mud and destroying the surface of the road. When the ground is frozen and a heavy rain or sudden thaw occurs the side ditch is the only means of getting rid of the surface water, for no matter how sandy or porous the soil may be, when filled with frost it is practically water tight, and the water which falls or forms on the surface must either remain there or be carried away by surface ditches at the sides of the road.
>
> A side ditch should have a gradually falling and even grade at the bottom, and broad, flaring sides to prevent the caving in of its banks. It can be easily cleared of snow, weeds, and rubbish; the water will run into it easily from each side, and it is not dangerous to wagons and foot travelers. It is, therefore, a much better ditch than the one shown in fig. 7, which represents the kind of ditch very often dug along the country roadside.

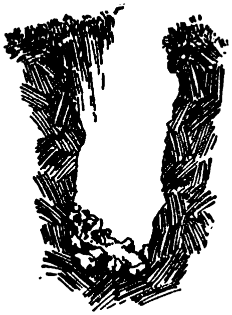
FIG. 7.—Roadside ditch dug by erosion.

Where the road is built on a grade some provision should be made to prevent the wash of the gutters into great, deep gullies, such as is seen in fig. 7. This can be done by paving the bottom and sides of the gutters with brick, river rocks, or field stone. In order to make the flow in such side ditches as small as possible it is advisable to construct outlets into the adjacent fields or to lay underground pipes or tile drains with openings into the ditches at frequent intervals.

The size of side ditches should depend upon the character of the soil and the amount of water they are expected to carry. If possible they should be located 3 feet from the edge of the traveled roadway, so that if the latter is 14 feet wide there will be 20 feet of clear space between ditches.

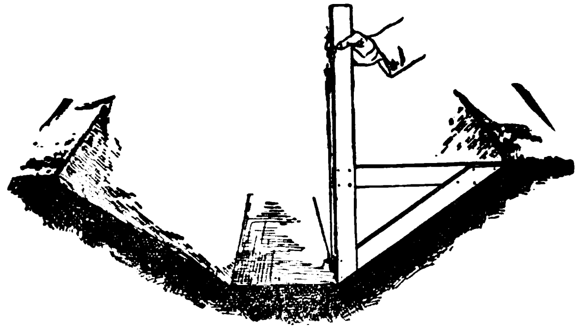
FIG. 8.—Proper form of surface ditch, showing manner of construction.

To make a ditch with even, flaring sides (fig. 8), so as to produce a neat job, it is good policy to use a rough gauge, like that shown in fig. 8. The gauge is made of light strips of wood about 3 inches in width and 1 inch thick. The upright strip should be about 4 feet long and the horizontal strip should be 18 inches in length, measured from the left side of the upright piece to the point of the gauge on the extreme right. The top of the horizontal strip should be 1 foot from the bottom point of the gauge. This gauge should be provided with a plumb and line, and by means of the upright strip is held vertical while the slope is made to correspond with the edges of the diagonal strip.

The bottom of the ditch may vary in width from 3 to 12 inches, or even more, as may be found necessary in order to carry the largest amount of water which is expected to flow through it at any one time. Sometimes the only ditches necessary to carry off the surface water are those made by the use of the road machines or road graders. The blade of the machine may be set at any desired angle, and when drawn along by horses cuts into the surface and moves the earth from the sides toward the center, forming gutters alongside and distributing the earth uniformly over the traveled way (fig. 23). Such gutters are liable to become clogged by brush, weeds, and other débris, or destroyed by passing wagons, and it is therefore better, when the space permits, to have the side ditches above referred to, even if the road be built with a road machine.

SUBDRAINAGE.

In order to have a good road it is just as necessary that water should not be allowed to attack the substructure from below as that it should not be permitted to percolate through it from above. Especially is the former provision essential in cold climates, where, if water is allowed to remain in the substructure the whole roadway is liable to become broken up and destroyed by frost and the wheels of vehicles. Therefore, where the road runs through low wet lands or over certain kinds of clayey soils surface drainage is not all that is necessary. Common side drains catch surface water and surface water only. Isaac Potter says:

> Many miles of road are on low, flat lands and on springy soils, and thousands of miles of prairie roads are, for many weeks in the year, laid on a wet subsoil. In all such cases, and, indeed, in every case where the nature of the ground is not such as to insure quick drainage, the road may be vastly benefited by under drainage. An under drain clears the soil of surplus water, dries it, warms it, and makes impossible the formation of deep, heavy, frozen crusts, which are found in every undrained road when the severe winter weather follows the heavy fall rains. This frost causes nine-tenths of the difficulties of travel in the time of sudden or long-continued thaws.
>
> Roads constructed over wet undrained lands are always difficult to manage and expensive to maintain, and they are liable to be broken up in wet weather or after frosts. It will be much cheaper in the long run to go to the expense of making the drainage of the subjacent soil and substructure as perfect as possible. There is scarcely an earth road in the United States which can not be so improved by surface or subdrainage as to yield benefits to the farmers a hundred times greater in value than the cost of the drains themselves.

Under drains are not expensive. On the contrary, they are cheap and easily made, and if made in a substantial way and according to the rules of common sense a good under drain will last for ages. Use the best tools and materials you can get (figs. 9 and 10); employ them as well as you know how, and wait result with a clear conscience. Slim fagots of wood bound together and laid lengthwise at the bottom of a carefully graded drain ditch will answer fairly well if stone or drain tile can not be had, and will be of infinite benefit to a dirt road laid on springy soils.

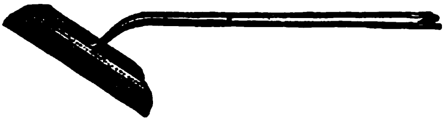

FIG. 9.—Miles's drainage scoop for preparing bottom of ditch for the tile drains.

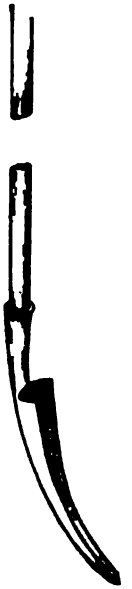

FIG. 10.—Instrument used for grading subdrain ditch to receive tile.

Subdrains should be carefully graded with a level (fig. 11) at the bottom to a depth of about 4 feet, and should have a continuous fall throughout their entire length of at least 6 inches for each 100 feet in length. If tile drains (fig. 12) can not be had, large, flat stones may be carefully placed so as to form a clear, open passage at the bottom for the flow of the water (fig. 13). The ditch should then be half filled with rough field stones, and on these a layer of smaller stones or gravel and a layer of sod, hay, gravel, cinders, or straw, or, if none of these can be had, of soil. If field stones or drain tile can not be procured, satisfactory results may be attained by the use of logs and brush, as seen in fig. 14.

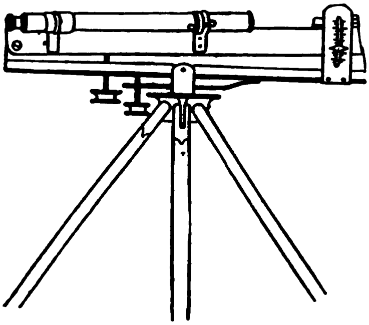

FIG. 11.—Harris's grade level which can be used by any farmer or road builder in establishing grades for roadways or in constructing surface drains or subdrains for roads or farms.

If there be springs in the soil which might destroy the stability of the road, they should, if possible, be tapped and the water carried under or along the side until it can be turned away into some side channel. Such drains may be made of bundles of brush (fig. 15), field stones (fig. 16), brick (fig. 17), or drain tiles. They should be so protected by straw, sod, or brush as to prevent the soil from washing in and clogging them.

DIFFERENT KINDS OF ROADS.

Most of the roads in this country are of necessity constructed of earth, while in a few of the richer and more enterprising communities the most important thoroughfares are surfaced with gravel, shell, stones, or other materials. Unless some new system for the improvement of public roads is adopted, the inability of rural communities to raise funds for this purpose will necessarily cause the construction of hard roads to be very gradual for some time to come. Until this new system is adopted the most important problem will be that of making the most of the roads which exist, rather than building new ones of specially prepared materials. The natural materials and the funds already available must be used with skill and judgment in order to secure the best results. The location, grades, and drainage having been treated in the preceding pages, the next and most important consideration is that of constructing and improving the various kinds of roads.

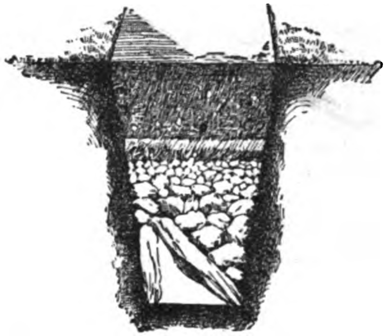
FIG. 13.—Subdrain made with field stones.

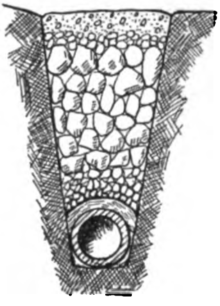
FIG. 12.—Subdrain constructed with drain tile and stone.

EARTH ROADS.

Of earth roads, as commonly built, it suffices to say that their present conditions should not be tolerated in communities where there are any other materials with which to improve them. Earth is the poorest of all road materials, aside from sand, and earth roads require more attention than any other kind of roads, and as a rule get less. At best, they possess so many defects that they should have all the attention and care of which their condition is susceptible. With earth alone, however, a very passable road can be made, provided the principles of location, drainage, and shape of surface, together with that of keeping the surface as smooth and firm as possible by rolling, be strictly adhered to. In fact a good earth road

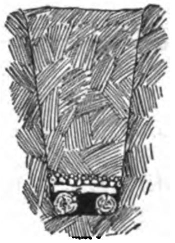
FIG. 14.—Subdrain constructed of logs and fagots of wood.

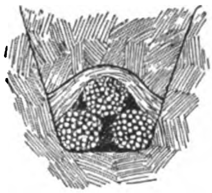
FIG. 15.—Subdrain made of bundles of brush for conveying spring water under or alongside roads.

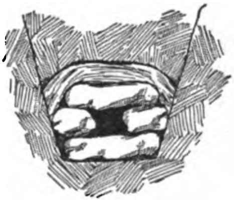
FIG. 16.—Subdrain made of field stone for conveying spring water under or alongside of roads.

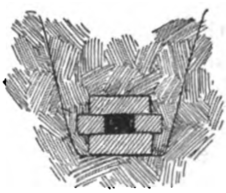
FIG. 17.—Subdrain made of bricks for conveying spring water under or alongside of roads.

is second to none for summer travel and superior to many of the so-called macadam or stone roads.

Drainage.—"Water is the great road destroyer," and too much attention can not be given to the surface and subdrainage of earth roads (fig. 18). The material of which their surfaces are composed is more susceptible to the action of water and more easily destroyed by it than any other highway material. Drainage alone will often change a bad road into a good one, while on the other hand the best road may be destroyed by the absence of good drains.

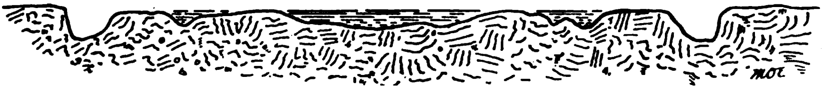

FIG. 18.—Cross section of a 14-foot road showing the result of improper construction and drainage. Note that the center of the road has become the lowest part and that water may collect on the surface, making the road practically impassable.

Rolling.—The same can be said of rolling, which is a very important matter in attempting to build or maintain a satisfactory earth road. If loose earth is dumped into the middle of the road and consolidated by traffic, the action of the narrow-tired wheels cuts it or rolls it into uneven ruts and ridges, which hold water, and ultimately results, if in the winter season, in a sticky, muddy surface, or if it be in dry weather, in covering the surface with several inches of dust. If, however, the surface be prepared with a road machine and properly rolled with a heavy roller, it can usually be made sufficiently firm and smooth to sustain the traffic without rutting, and resist the penetrating action of the water. Every road is made smoother, harder, and better by rolling (figs. 19 and 20). Such rolling should be done in damp weather, or if that is not possible, the surface should be sprinkled if the character of the soil requires such aid for its proper consolidation.

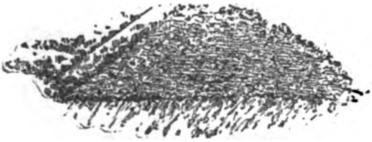

FIG. 19.—Section of loose unrolled earth road.

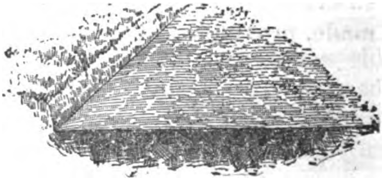

FIG. 20.—Section of compact, smooth earth road made solid by use of roller.

Construction.—In constructing new earth roads all stumps, brush, vegetable matter, rocks, and bowlders should be removed from the surface and the resulting holes filled in with suitable material, carefully and thoroughly tamped or rolled, before the road embankment is commenced. No perishable material should be used in forming the permanent embankments. Where possible the longitudinal grade should be kept down to 1 foot in 30 feet, and should under no circumstances exceed 1 in 20, while that from center to sides should be maintained at 1 foot in 20 feet.

Wherever the subgrade soil is found unsuitable it should be removed and replaced with good material rolled to a bearing, i. e., so as to be smooth and compact. The roadbed having been brought to the required grade and crown, should be rolled several times to compact the surface. All inequalities discovered during the rolling should be leveled up and rerolled. On the prepared subgrade the earth should be spread, harrowed it necessary, and then rolled to a bearing by passing the unballasted road roller a number of times over every portion of the surface of the section.

In level countries and with narrow roads, enough material may be excavated to raise the roadway above the subgrade in forming the side ditches by means of road machines. If not, the required earth should be obtained by widening the side excavations, or from cuttings on the line of the new roadway, or from pits close by, elevating graders and modern dumping or spreading wagons being preferably used for this purpose. When the earth is brought up to the final height, it is again harrowed, then trimmed by means of road levelers or road machines, and ultimately rolled to a solid and smooth surface with road rollers gradually increased in weight by the addition of ballast.

No filling should be brought up in layers exceeding 9 inches in depth. During the rolling, sprinkling should be attended to wherever the character of the soil requires such aid. The cross section of the roadway must be maintained during the last rolling stage by the addition of earth as needed. On clay soils a layer of sand, gravel, or ashes spread on the roadway will prevent the sticking of the clay to the roller. As previously explained, the finishing touches to the road surface should be given by a heavy roller. (Fig. 21.)

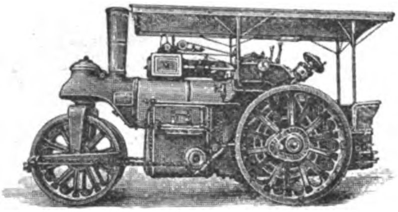
FIG. 21.—Russell steam road roller built in all sizes and can be used for rolling roads, crushing stone, sawing wood, thrashing, etc.

Before the earth road is opened to traffic, deep and wide side ditches, like that seen in fig. 8, should be constructed, with a fall throughout their entire length of at least 1 in 120. They should be cleaned and left with the drain tiling connections, if any, in good working order.

Clay soils, as a rule, absorb water quite freely and soften when saturated, but water does not readily pass through them; hence they are not easily subdrained. When used alone, clay is the least desirable of all road materials, but roads constructed over clay soils may be treated with sand or small gravel, from which a comparatively hard and compact mass is formed which is nearly impervious to water. Material of this character found in the natural state, commonly known as hardpan, makes, when properly applied, a very solid and durable surface. In soil composed of a mixture of sand, gravel, and clay all that is neces sary to make a good road of its kind is to "crown" the surface, keep the ruts and hollows filled, and the ditches open and free.

Filling the ruts.—Roads are prone to wear in ruts, and when hollows and ruts begin to make their appearance on the surface of an earth road, great care should be used in selecting new material with which they should be immediately filled, because a hole which could have been filled at first with a shovel full of material would soon need a cart full. It should, if possible, be of a gravelly nature, entirely free from vegetable earth, muck, or mold. Sod or turf should not be placed on the surface, neither should the surface be renewed by throwing upon it the wornout material from the gutters alongside. This last injunction, if rightly observed and the proper remedy applied, would doubtless put an end to the deplorable condition of thousands of miles of earth roads in the United States.

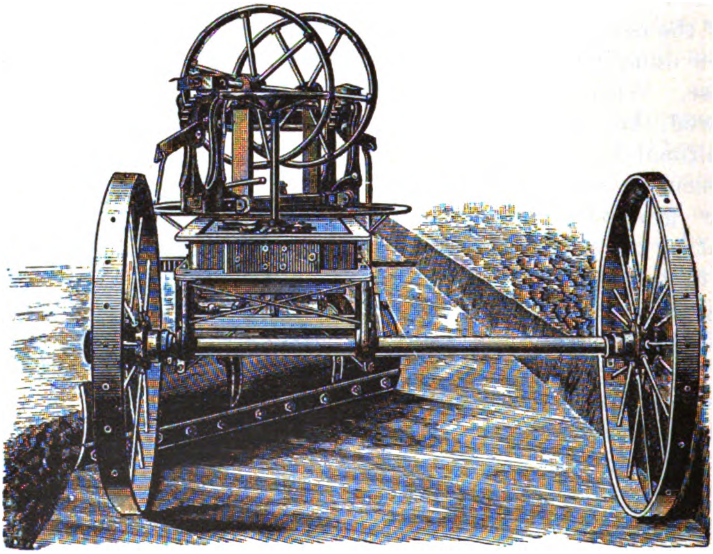

FIG. 22.—Champion road machine at work on an earth road.

A roadmaker should not go to the other extreme and fill up ruts and holes with stone or large gravel. In many cases it would be wiser to dump such material in the river. These stones do not wear uniformly with the rest of the material, but produce bumps and ridges, and in nearly every case result in making two holes instead of one. Every hole or rut in a roadway, if not tamped full of some good material like that of which the road is constructed, will become filled with water, and finally with mud and water, and will be dug deeper and wider by each passing vehicle.

The work of maintaining earth roads will be much increased by lack of care in properly finishing the work. The labor and money spent in rolling a newly made road may save many times that amount of labor and money in making future repairs. After the material has been placed it should not be left for the traffic to consolidate or for the rains to wash off into the ditches, but should be carefully formed and surfaced, and then, if possible, rolled. The rolling not only consolidates the material, but puts the roadbed in proper shape for travel immediately. If there is anything more trying on man or beast than to travel over an unimproved road, it must be to travel over one which has just been "worked" by the antiquated methods now in vogue in many of the States.

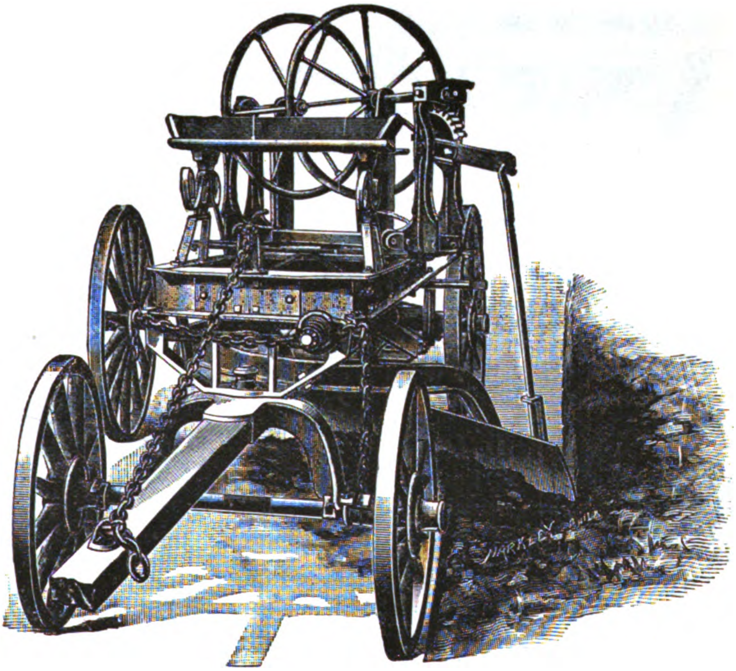

FIG. 23.—Champion road machine preparing earth road.

Repairs by road machines.—The traveled way should never be repaired by the use of plows or scoops. The plow breaks up the compact surface which age and traffic has made tolerable. Earth roads can be rapidly repaired by a judicious use of road machines (figs. 22 and 23) and road rollers. The road machine places the material where it is most needed, and the roller (fig. 24) compacts and keeps it there. The labor-saving machinery now manufactured for road building is just as effectual and necessary as the modern mower, self-binder, and thrasher. Road graders and rollers are the modern inventions necessary to permanent and economical construction. Two men with two teams can build more road in one day with a grader and roller than fifty men can with picks and shovels, and do it more uniformly and more thoroughly.

Use of wide tires.—Doubtless the best way to keep an earth road, or any road, for that matter, in repair is by the use of wide tires (fig. 25) on all wagons carrying heavy burdens. Water and narrow tires aid each other in destroying streets, macadam, gravel, and earth roads. Narrow tires are also among the most destructive agents to the fields, pastures, and meadows of farms, while on the other hand wide tires are road-makers; they roll and harden the surface, and every loaded wagon becomes in effect a road roller. Nothing so much tends to the improving of a road as the continued rolling of its surface.

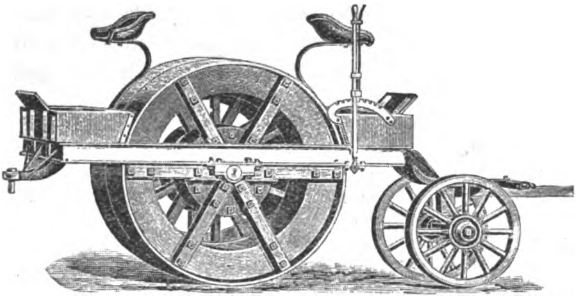

FIG. 24.—Champion reversible road roller, to be drawn by horses, and built in four different weights, 2½, 3½, 4½, and 5½ tons.

Tests recently made at the experiment stations in Utah and Missouri show that wide tires not only improve the surface of roads but that under ordinary circumstances less power is required to pull a wagon on which wide tires are used. The introduction in recent years of a wide metallic tire (fig. 26), which can be placed on any narrow-tired wheel at the cost of $2 each, has removed one very serious objection to the proposed substitution of broad tires for the narrow ones now in use.

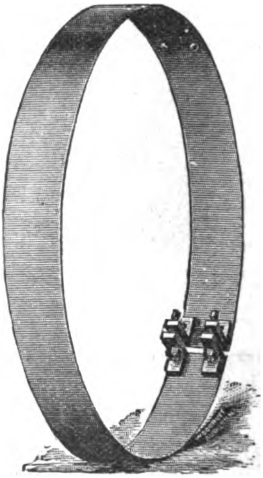

FIG. 25.—The "Richardson" adjustable wide tire.

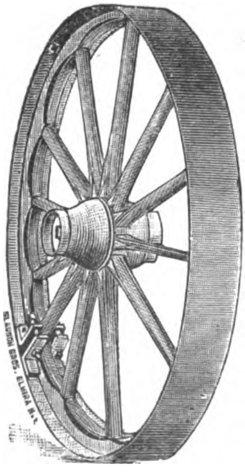

FIG. 26.—The "Richardson" adjustable tire in place on wheel of farm wagon.

Time to repair roads.—Repairs on earth roads should be attended to particularly in the spring of the year, but the great mistake of letting all the repairs go until that time should not be made. The great want of the country road is daily care, and the sooner we do away with the system of "working out" our road taxes, and pay such taxes in money, the sooner will it be possible to build improved roads and to hire experts to keep them constantly in good repair. Roads could then secure attention when such attention is most needed. If they are repaired only annually or semiannually they are seldom in good condition, but when they are given daily or weekly care they are most always in good condition, and, moreover, the second method costs far less than the first. A portion of all levy tax money raised for road purposes should be used in buying improved road machinery, and in constructing each year a few miles of improved stone or gravel roads.

SAND ROADS.

The only exceptions to the instructions given on road drainage is found in the attempt to improve a sand road. The more one improves the drainage of a sand road the more deplorable becomes its condition. Nothing will ruin one quicker than to dig a ditch on each side and drain all the water away. The best way to make such a road firm is to keep it constantly damp. Very bushy or shady trees alongside such roads prevent the evaporation of water.

The usual way of mending roads which run over loose sandy soils is to cover the surface with tough clay or mix the clay and sand together. This is quite an expensive treatment if the clay has to be transported a great distance, but the expense may be reduced by improving only 8 or 10 feet or half of the roadway.

ROADS OF SAWDUST, TANBARK, ETC.

Any strong, fibrous substance, and especially one which holds moisture, such as the refuse of sugar cane or sorghum, and even common straw, flax, or swamp grass will be useful. Spent tan is of some service, and wood fiber in any form is excellent. The best is the fibrous sawdust made in sawing shingles by those machines which cut lengthwise of the fiber into the side of the block. Sawdust is first spread on the road from 8 to 10 inches deep, and this is covered with sand to protect the road against fire lighted from pipes or cigars carelessly thrown or emptied on the roadbed. The sand also keeps the sawdust damp. The dust and sand soon become hard and packed, and the wheels of the heaviest wagons make but little impression upon the surface. The roadbed appears to be almost as solid as a plank road, but is much easier for the teams. The road prepared in this manner will remain good for four or five years and will then require renewing in some parts. The ordinary lumber sawdust would not be so good, of course, but if mixed with planer shavings might serve fairly well.

CORDUROY ROADS.

Roads built of poles or logs laid across the roadway are called corduroy roads, because of their corrugated or ribbed appearance. Like earth roads, they should never be built where it is possible to secure any other good material, but, as is frequently the case in swampy, timbered regions, other material is unavailable, and as the road would be absolutely impassable without them at certain seasons of the year, it is well to know how to make them. Roads of this character should be 15 or 16 feet wide, so as to enable wagons to pass each other. Logs are superior to poles for this purpose and should be used if possible. The following in regard to the construction of corduroy roads is from Gilmore's Roads, Streets, and Pavements:

> The logs are all cut the same length, which should be that of the required width of the road, and in laying them down such care in selection should be exercised as will give the smallest joints or openings between them. In order to reduce as much as possible the resistance to draft and the violence of the repeated shocks to which vehicles are subjected upon these roads, and also to render its surface practicable for draft animals, it is customary to level up between the logs with smaller pieces of the same length but split to a triangular cross-section. These are inserted with edges downward in the open joints, so as to bring their surface even with the upper sides of the large logs, or as nearly so as practicable.
>
> Upon the bed thus prepared a layer of brush wood is put, with a few inches in thickness, with soil or turf on top to keep it in place. This completes the road. The logs are laid directly upon the natural surface of the soil, those of the same or nearly of the same diameter being kept together, and the top covering of soil is excavated from side ditches.
>
> Cross drains may usually be omitted in roads of this kind, as the openings between the logs, even when laid with utmost care, will furnish more than ample waterway for drainage from the ditch on the upper to that on the lower side of the road. When the passage of a creek of considerable volume is to be provided for, and in localities subject to freshets, cross-drains or culverts are made wherever necessary by the omission of two or more logs, the openings being bridged with planks, split rails, or poles laid transversely to the axis of the road and resting on cross beams notched into the logs on either side.

HARD ROADS.

The essential requirement of a good road is that it should be firm and unyielding at all times and in all kinds of weather, so that its surface may be smooth and impervious to water. Earth roads at best fulfill none of these requirements, unless they be covered with some artificial material.

On a well-made gravel road one horse can draw twice as large a load as he can on a well-made earth road. On a hard smooth stone road one horse can pull as much as four horses will on a good earth road. (Fig. 27.)

If larger loads can be hauled and better time made on good hard roads than on good earth ones, the area and the number of people benefited is increased in direct proportion to the improvement of their surface. Moreover, it is evident that a farm 4 or 5 miles from the market or shipping point located on or near a hard road is virtually nearer the market than one situated only 2 or 3 miles away, but located on a soft and yielding road. Hard roads are divided here into three classes—gravel, shell, and stone, and their construction is treated in the following pages.

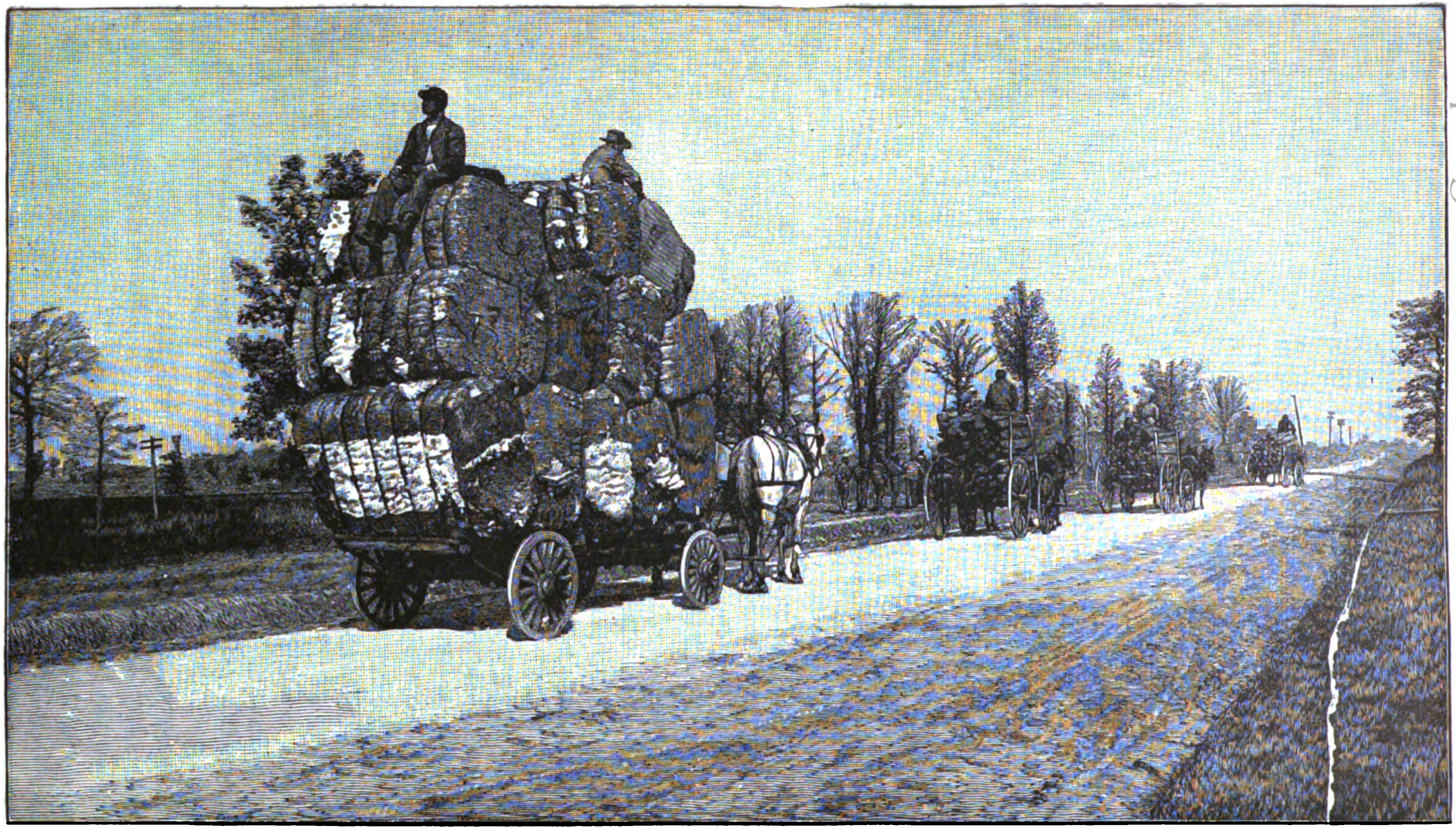

FIG. 27.—Loads on macadamized road in Mecklenburg County, N. C., where formerly on earth road two bales of cotton made a good load for two mules in fairly good weather; now on macadamized road the same two mules haul ten bales of cotton in any weather.

GRAVEL ROADS.

Although it is impracticable, and in many cases impossible, for communities to build good stone roads, a surface of gravel may frequently be used to advantage, giving far better results than could be attained by the use of earth alone. Where beds of good gravel are available this is the simplest, cheapest, and most effective method of improving country roads.

Seaside and river gravel.—In connection with the building and maintenance of gravel roads the most important matter to consider is that of selecting the proper material. A small proportion of argillaceous sand, clayey, or earthy matter contained in some gravel enables it to pack readily and consolidate under traffic or the road roller. Seaside and river gravel, which is composed usually of rounded, waterworn pebbles, is unfit for surfacing roads. The small stones of which they are composed having no angular projections or sharp edges, easily move or slide against each other and will not bind together, and even when mixed with clay may turn freely, causing the whole surface to be loose, like materials in a shaken sieve.

Inferior qualities of gravel can sometimes be used for foundations; but where it becomes necessary to employ such material even for that purpose it is well to mix just enough sandy or clayey loam to bind it firmly together. For the wearing surface or the top layer the pebbles should, if possible, be comparatively clean, hard, angular, and tough, so that they will readily consolidate, and will not be easily pulverized by the impact of traffic into dust and mud. They should be coarse, varying in size from half an inch to an inch and one-half.

Blue gravel and bank gravel.—Where blue gravel or hardpan and clean bank gravel are procurable, a good road may be made by mixing the two together. Pit gravel or gravel dug from the earth as a rule contains too much earthy matter. This may, however, be removed by sifting. For this purpose two sieves are necessary, through which the gravel should be thrown. The meshes of one sieve should be one and one-half or two inches in diameter, while the meshes of the other should be three-fourths of an inch. All pebbles which will not go through the one and one-half inch meshes should be rejected or broken so that they will go through. All material which sifts through the three-fourths inch meshes should be rejected for the road, but may be used in making side paths. The excellent road which can be built from materials prepared in this way is so far superior to the one made of the natural clayey material that the expense and trouble of sifting is many times repaid.

The best gravel for road building stands perpendicular in the bank; that is, when the pit has been opened up the remainder stands compact and firm and can not be dislodged except by use of the pick, and when it gives way falls in great chunks or solid masses. Such materia usually contains tough angular gravel with just enough cementing properties to enable it to readily pack and consolidate, and requires no further treatment than to place it properly on the prepared roadbed.

Gravel on earth roads.—Some earth roads may be greatly improved by covering the surface with a layer of 3 or 4 inches of gravel, and sometimes even a thinner layer may prove of very great benefit if kept in proper repair. The subsoil of such roadway ought, however, to be well drained, or of a light and porous nature. Roads constructed over clay soils require a layer of at least 6 inches of gravel. The gravel must be deep enough to prevent the weight of traffic forcing the surface material into weak places in the clay beneath, and also to prevent the surface water from percolating through and softening the clay and causing the whole roadway to be torn up.

Owing to a lack of knowledge regarding construction, indifference, or carelessness in building or improving, roads made of gravel are often very much worse than they ought to be. Some of them are made by simply dumping the material into ruts, mud holes, or gutter-like depressions, or on unimproved foundation, and are left thus for traffic to consolidate; while others are made by covering the surface with inferior material without any attention being paid to the fundamental principles of drainage. As a result of such thoughtless and haphazard methods the road usually becomes rougher and more completely covered with holes than before.

Grade and width of gravel roads.—In constructing a gravel road the roadbed should first be brought to the proper grade. Ordinarily an excavation is then made to the depth of 8 or 10 inches, varying in width with the requirements of traffic. For a farm or farming community the width need not be greater than 10 or 12 feet. A roadway which is too wide is not only useless, but the extra width is a positive damage. Any width beyond that needed for the traffic is not only a waste of money in constructing the road, but is the cause of a never-ending expense in maintaining it. The surface of the roadbed should preferably have a fall from the center to the sides the same as that to be given the finished road, and should, if possible, be thoroughly rolled and consolidated until perfectly smooth and firm.

A layer, not thicker than 4 inches, of good gravel, such as that recommended above, should then be spread evenly over the prepared roadbed. Such material is usually carried upon a road in wheelbarrows or dumpcarts, and then spread in even layers with rakes, but the latest and best device for this purpose is a spreading cart (fig. 36).

Rolling the road.—If a roller can not be had, the road is thrown open to traffic until it becomes fairly well consolidated; but it is impossible to properly consolidate materials by the movement of vehicles over the road, and if this means is pursued constant watchfulness is necessary to prevent unequal wear and to keep the surface smooth and free from ruts. The work may be hastened and facilitated by the use of a horse roller (fig. 28) or light steam roller (fig. 29); and of course far better results can be accomplished by this means. If the gravel be too dry to consolidate easily it should be kept moist by sprinkling. It should not, however, be made too wet, as any earthy or clayey matter in the gravel is liable to be dissolved.

As soon as the first layer has been properly consolidated a second, third and, if necessary, fourth layer, each 3 or 4 inches in thickness, is spread on and treated in the same manner, until the road is built up to the required thickness and cross section. The thickness in most cases need not be greater than 10 or 12 inches, and the fall from the center to the sides ought not to be greater than 1 foot in 20 feet, or less than 1 in 25.

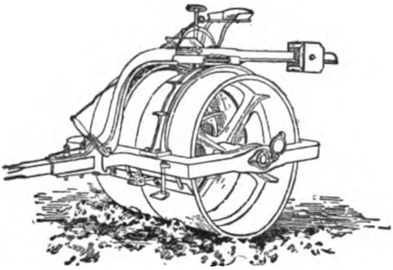
FIG. 28.—The Austin reversible horse roller, provided with roller bearings to lighten draft, and weight plates for increasing weight.

The last or surface layer should be rolled until the wheels of heavily loaded vehicles passing over it make no visible impression. If the top layer is deficient in binding material and will not properly consolidate, a thin layer, not exceeding one inch in thickness, of sand or gravelly loam or clay should be evenly spread on and slightly sprinkled if in dry weather, before the rolling is begun. Hardpan or stone screenings are much preferred for this purpose if they can be had.

The tendency of the material to spread under the roller and work toward the sides can be resisted by rolling that portion nearest the gutters first. To give the surface the required form and to secure uniform density, it is necessary at times to employ men with rakes to fill any depressions which may form.

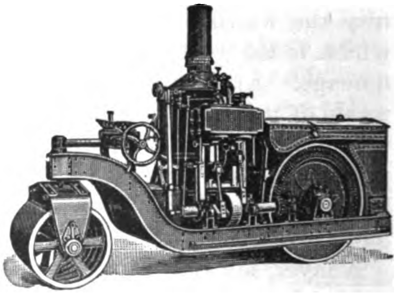
FIG. 29.—Iroquois steam road roller, built in all sizes.

Maintenance.—In order to maintain a gravel road in good condition, it is well to keep piles of gravel (fig. 30) alongside at frequent intervals, so that the person who repairs the road can get the material without going too far for it. As soon as ruts or holes appear on the surface some of this good fresh material should be added and tamped into position or kept raked smooth until properly consolidated.

If the surface needs replenishing or rounding up, as is frequently the case with new roads after considerable wear, the material should be applied in sections or patches, raked and rolled until hard and smooth.

Care must be taken that the water from higher places does not drain onto or run across the road. The side ditches, culverts, and drains should be kept open and free from débris.

SHELL ROADS.

In many of the Eastern and Southern States road stones do not exist; neither is it possible to secure good coarse gravel. No such material can be secured except at such an expense for freight as to practically preclude its use for road building. Oyster shells can be secured cheaply in most of these States, and when applied directly upon sand or sandy soil, 8 or 10 inches in thickness, they form excellent roads for pleasure driving and light traffic. Shells wear much more rapidly than broken stone or gravel of good quality, and consequently roads made of them require more constant attention to keep them in good order. In most cases they should have an entirely new surface every three or four years. When properly maintained they possess many of the qualities found in good stone or gravel roads, and so far as beauty is concerned they can not be surpassed.

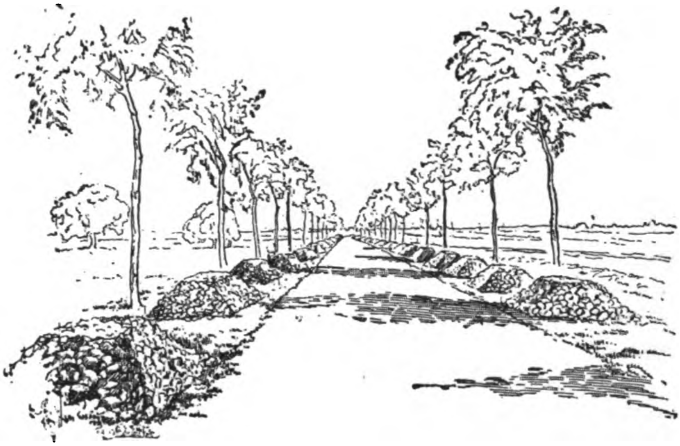

FIG. 30.—Road in France between Fontainebleau and Sens, illustrating method of placing stone and gravel for repaving and resurfacing, and the planting of trees at a safe distance from the roadside.

STONE ROADS.

The greatest obstacles to good stone road construction in most places in the United States are the existing methods of building and systems of management, whereby millions of dollars are annually wasted in improper construction or in making trifling repairs on temporary structures.

The practice of using too soft, too brittle, or rotten material on roads can not be too severely condemned. Some people seem to think that if a stone quarries easily, breaks easily, and packs readily, it is the very best stone for road building. This practice, together with that of placing the material on unimproved foundations and leaving it thus for traffic to consolidate, has done a great deal to destroy the confidence of many people in stone roads. There is no reason in the world why a road shou d not last for ages if it is built of good material and kept in proper repair. If this is not done the money spent is more than wasted. It is more economical, as a rule, to bring good materials a long distance by rail or water than to employ inferior ones procured close at hand.

The durability of roads depends largely upon the power of the materials of which they are composed to resist those natural and artificial forces which are constantly acting to destroy them. The fragments of which they are constructed are liable to be attacked in cold climates by frost, and in all climates by water and wind. If composed of stone or gravel the particles are constantly grinding against each other and being exposed to the impact of the tires of vehicles and the feet of animals. Atmospheric agencies are also at work decomposing and disintegrating the material. It is obviously necessary, therefore, that great care be exercised in selecting for the surfacing of roads those stones which are less liable to be destroyed or decomposed by these physical, dynamical, and chemical forces.

Useful stones for road building.—Siliceous materials, those composed of flint or quartz, although hard, are brittle and deficient in toughness. Granite is not desirable because it is composed of three materials of different natures, viz: quartz, feldspar, and mica, the first of which is brittle, the second liable to decompose rapidly, and the third laminable or of a scaly or layerlike nature. Some granites which contain hornblende instead of feldspar are desirable. The darker the variety the better. Gneiss, which is composed of quartz, feldspar, and mica, more or less distinctly slaty, is inferior to granite. Mica-slate stones are altogether useless. The argillaceous slates or clayey slates make a smooth surface, but one which is easily destroyed when wet. The sandstones are utterly useless for road building. The tougher limestones are very good, but the softer ones, though they bind and make a smooth surface very quickly, are too weak for heavy loads; they wear, wash, and blow away very rapidly.

The materials employed for surfacing roads should be both hard and tough, and should possess by all means cementing and recementing qualities. For the Southern States, where there are no frosts to contend with, the best qualities of limestone are considered quite satisfactory so far as the cementing and recementing qualities are concerned, but in most cases roads built of this class of material do not stand the wear and tear of traffic like those built of trap rock, and when exposed to the severe northern winters such material disintegrates very rapidly. In fact, trap rock, "nigger heads," technically known as diabase, and diorites, are considered by most road engineers of long experience to be the very best stones for road building. Trap rocks as a rule possess all the qualities most desired for road stones. They are hard and tough, and when properly broken to small sizes and rolled thoroughly, cement and consolidate into a smooth, hard crust which is impervious to water, and the broken particles are so heavy that they are not readily blown or washed away.

Unfortunately the most useful stones for road building are the most difficult to prepare, and as trap rocks are harder to break than any other stones they usually cost more. The foundation or lower courses may be formed of some of the softer stones, like gneiss or limestone, but trap rock should be used for the wearing surface, if possible, even if it has to be brought from a distance.

As to construction of macadam roads, Mr. Potter says:

> In the construction of a macadam road in any given locality, the question of economy generally compels us to use a material found near at hand, and where a local quarry does not exist field stone and stone gathered from the beds of rivers and small streams may often be made to serve every purpose. Many of the stones and boulders thus obtained are of trap rock, and in general it may be said that all hard field and river stones, if broken to a proper size, will make fairly good and sometimes very excellent road metal. No elaborate test is required to determine the hardness of any given specimen. A steel hammer in the hands of an intelligent workman will reveal in a general way the relative degree of toughness of two or more pieces of rock. Field and river stone offer an additional advantage in that they are quickly handled, are generally of convenient size, and are more readily broken either by hand or by machine than most varieties of rock which are quarried in the usual way.

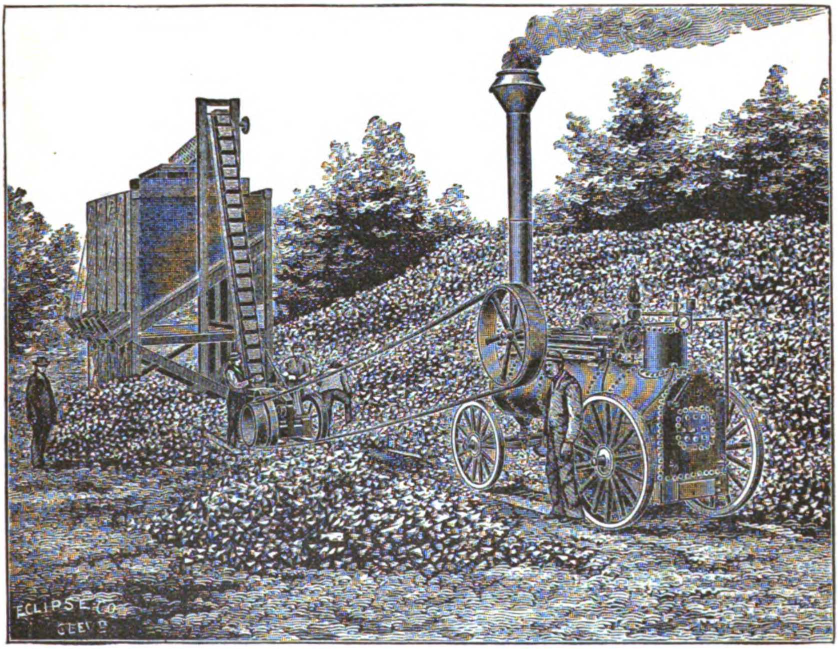

FIG. 31.—Complete Climax crushing plant in operation at Towanda, Pa.

It is a simple task to break stone for macadam roadways, and by the aid of modern inventions it can be done cheaply and quickly. Hand-broken stone is fairly out of date and is rarely used in America where any considerable amount of work is to be undertaken. Stone may be broken by hand at different points along the roadside where repairs are needed from time to time, but the extra cost of production by this method forbids its being carried on where extended work is undertaken. Hand-broken stone is generally more uniform in size, more nearly cubical in shape, and has sharper angles than that broken by machinery, but the latter, when properly assorted or screened, has been found to meet every requirement.

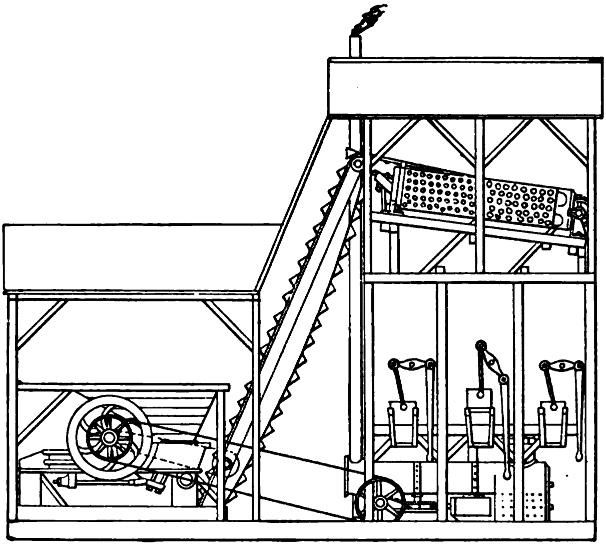

FIG. 32.—Stationary crushing plant. Elevator, screen, and bunkers complete.

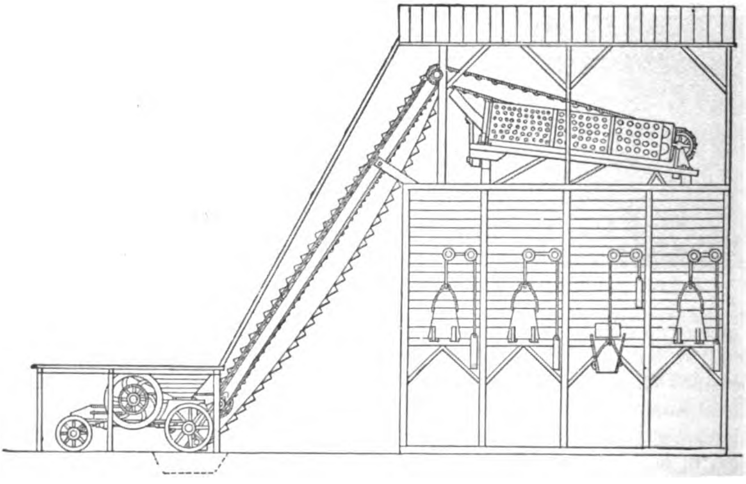

FIG. 33.—Semistationary crushing plant. Elevators, screen, and bunkers complete.

Stone crushers.—A good crusher (fig. 31) driven by eight horsepower will turn out from forty to eighty cubic yards of 2-inch stone per day of ten hours, and will cost from $400 upward, according to quality.

Some crushers are made either stationary (see fig. 32), semi-stationary (fig. 33), or portable (fig. 34), according to the needs of the purchaser, and for country-road work it is sometimes very desirable to have a portable crusher to facilitate its easy transfer from one part of the town to another. The same portable engine that is used in thrashing, sawing wood, and other operations requiring the use of steam power may be used in running a stone crusher, but it is best to remember that a crusher will do its best and most economical work when run by a machine having a horsepower somewhat in excess of the power actually required.

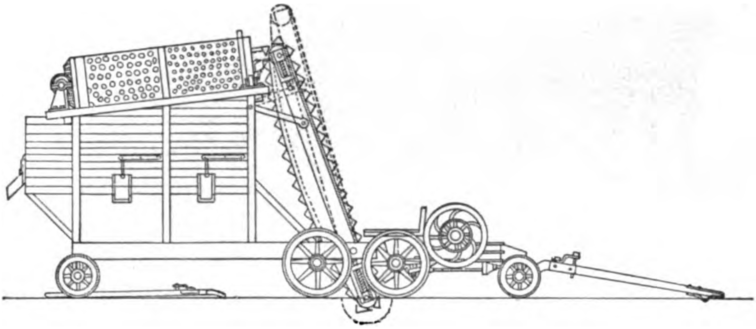

FIG. 34.—Portable crushing plant. Elevator, screen, and bunkers complete.

Screening the stone.—As the stone comes from the breaker the pieces will be found to show a considerable variety in size, and by many practical roadmakers it is regarded as best that these sizes should be assorted and separated, since each has its particular use. To do this work by hand would be troublesome and expensive and screens are generally employed for that purpose. Screens are not absolutely necessary, and many roadmakers do not use them; but they insure uniformity in size of pieces, and uniformity means in many cases superior wear, smoothness, and economy. Most of the screens in common use to-day are of the rotary kind. In operating, they are generally so arranged that the product of the crusher falls directly into the rotary screen, which revolves on an inclined axis and empties the separate pieces into small bins below the crusher. A better form (fig. 35) for many purposes includes

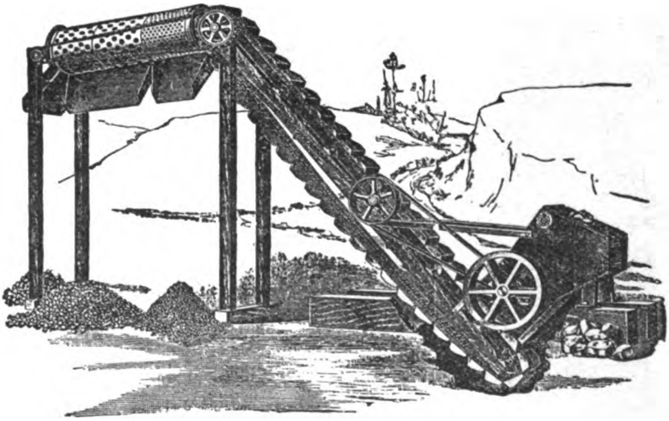

FIG. 35.—Stationary Champion rock crusher, showing apparatus for separating stone into proper sizes.

a larger and more elaborate outfit, in which the stone is carried by an elevator to the screen and by the screen emptied into separate bins (figs. 32, 33, and 34) according to the respective sizes. From the bins it is easily loaded into wagons or spreading carts (fig. 36) and hauled to any desired point along the line of the road.

The size to which stone should be broken depends upon the quality of the stone, the amount of traffic to which the road will be subjected, and to some extent upon the manner in which the stone is put in place. If a hard tough stone is employed it may be broken into rough cubes or pieces of about 1½ inches in largest face dimensions, and when broken to such a size the product of the crusher may generally be used to good advantage without the trouble of screening, since dust "tailings" and fine stuff do not accumulate in large quantities in the breaking of the tougher stone.

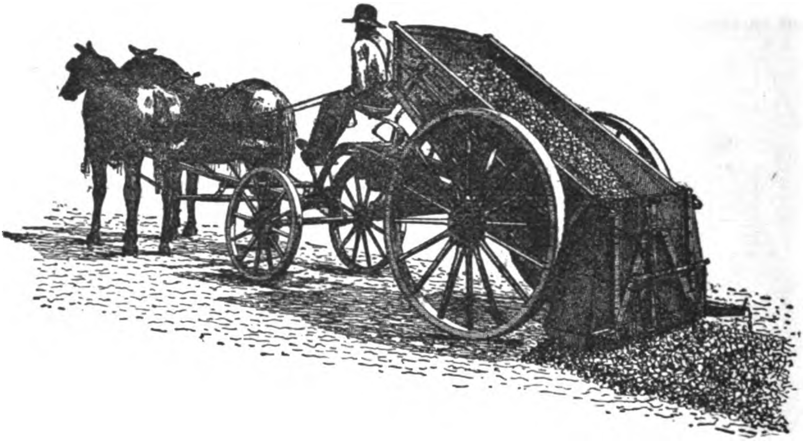

FIG. 36.—Champion distributing cart in operation.

If only moderate traffic is to be provided for the harder limestones may be broken so the pieces will pass through a 2-inch ring, though sizes running from 2¼ to 2½ inches will insure a more durable roadway, and if a steam roller is used in compacting the metal it will be brought to a smooth surface without much trouble. As a rule it may be said that to adhere closely to a size running from 2¼ to 2½ inches in largest face dimensions, and to use care in excluding too large a proportion of small stuff as well as all pieces of excessive size, will insure a satisfactory and durable macadam road.

FIG. 37.—John L. Macadam.

Macadam insisted that no large stone should ever be employed in road making, and, indeed, most modern road builders practice his principle that "small angular fragments are the cardinal requirements." As a general rule it has been stated that no stone larger than a walnut should be used for the surfacing of roads.

The macadam and telford methods.—Stone roads are built in most cases according to the principles laid down by John L. Macadam (fig. 37), while some are built by the methods advocated by Telford. The most important difference between these two principles of construction relates to the propriety or necessity of a paved foundation beneath the crust of broken stone. Telford advocated this principle, while Macadam strongly denied its advantages.

In building roads very few iron-clad rules can be laid down for universal application; skill and judgment must be exercised in designing and building each road so that it will best meet the requirements of the place it is to occupy. The relative value of the telford and macadam systems can most always be determined by the local circumstances, conditions, and necessities under which the road is to be built. The former system seems to have the advantage in swampy, wet places, or where the soil is in strata varying in hardness, or where the foundation is liable to get soft in spots. Under most other circumstances experienced road builders prefer the macadam construction, not only because it is considered best, but also because it is much cheaper.

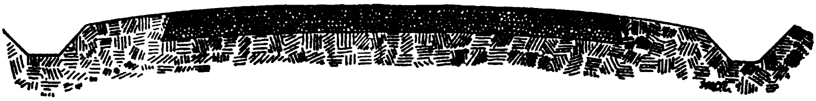
FIG. 38.—*Cross section of macadam road showing a compact foundation of earth supporting a solid and durable stone surface.*

Macadam construction.—The macadam road (fig. 38) consists of a mass of angular fragments of rock deposited usually in layers upon the roadbed or prepared foundation and consolidated to a smooth, hard surface produced by the passage of vehicles or by use of a road roller (fig. 39). The thickness of this crust varies with the soil, the nature of the stone used, and the amount of traffic which the road is expected to have. It should be so thick that the greatest load will not affect the foundation. The weight usually comes upon a very small part of the surface, but is spread over a large area of the foundation, and the thicker the crust the more uniformly will the load be distributed over the foundation.

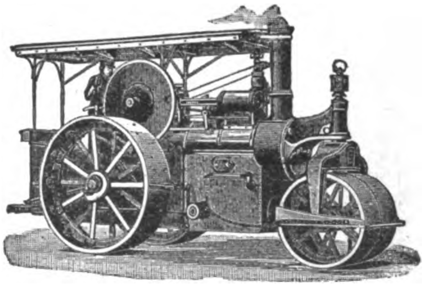
FIG. 39.—Buffalo Pitts steam road roller, sizes. 10, 12, and 15 tons.

Macadam earnestly advocated the principle that all artificial road building depended wholly for its success upon the making and maintaining of a solid dry foundation and the covering of this foundation with a durable waterproof coating or roof of broken stone. The foundation must be solid and firm; if it be otherwise the crust is useless. A road builder should always remember that without a durable foundation there is no durable road. Hundreds of miles of macadam roads are built in the United States each year on unimproved or unstable foundations and almost as many miles go to pieces for this same reason. Says Macadam:

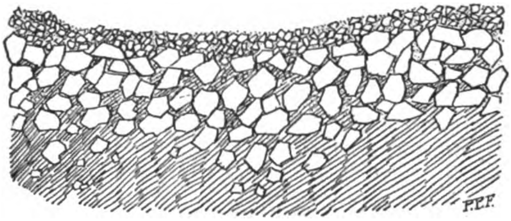

Fig. 40.—Cross section of macadam road showing result of placing stone on loose or wet earth foundation.

> The stone is employed to form a secure, smooth, water-tight flooring, over which vehicles may pass with safety and expedition at all seasons of the year. Its thickness should be regulated only by the quality of the material necessary to form such a flooring and not at all by any consideration as to its own independent power of bearing weight. * * * The erroneous idea that the evils of an underdrained, wet, clayey soil can be remedied by a large quantity of materials has caused a large part of the costly and unsuccessful expenditures in making stone roads.

Application of the material.—The evils from improper construction of stone roads are even greater than those resulting from the use of improper material. Macadam never intended that a heterogeneous conglomeration of stones and mud (fig. 40) should be called a macadam road. The mistake is often made of depositing broken stone on an old road without first preparing a suitable foundation. The result, in

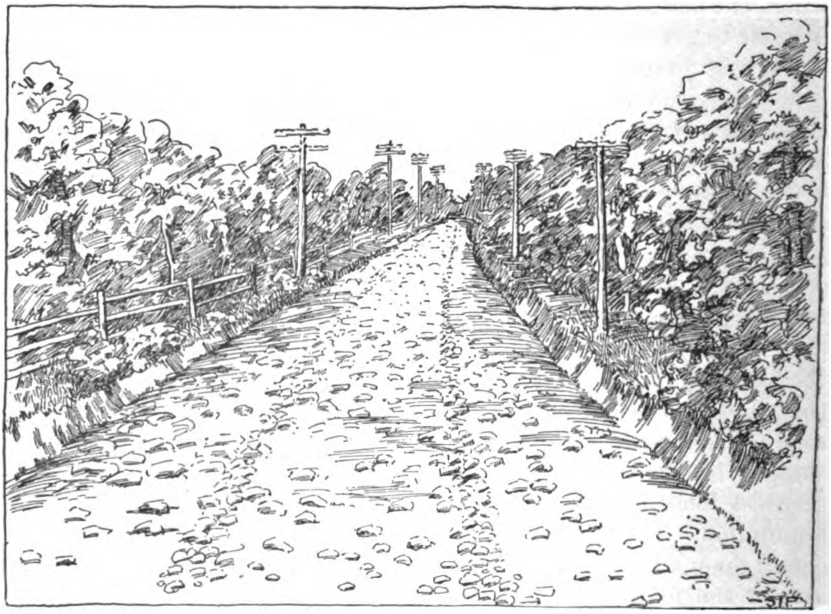

Fig. 41.—Bad condition of road resulting from attempt at macadam construction with large and small broken stone. Large stones have worked out to the surface (drawn from photograph).

most cases, is that the dirt and mud prevent the stone from packing and by the action of traffic ooze to the surface, while the stones sink deeper and deeper, leaving the road as bad as before.

Another great mistake is often made of spreading large and small stones over a well-graded and well-drained foundation and leaving them thus for traffic to consolidate. (See fig. 41.) The surface of a road left in this manner is often kept in constant turmoil by the larger stones, which work themselves to the surface and are knocked hither and thither by the wheels of vehicles and the feet of animals. These plans of construction can not be too severely condemned.

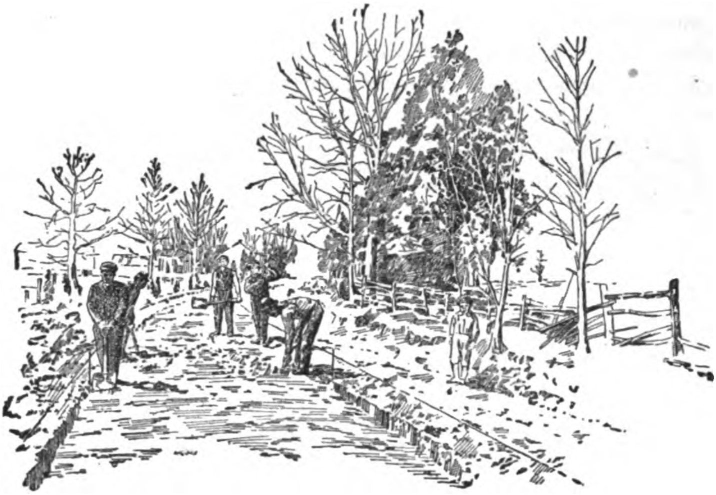

FIG. 42.—Excavating and preparing roadbed for macadam surface (drawn from photograph).

The roadbed (fig. 42) should be first graded, then carefully surface-drained. The earth should then be excavated to the depth to which material is to be spread on, and the foundation properly shaped and sloped each way from the center so as to discharge any water which may percolate through. This curvature should conform to the curvature of the finished road. A shouldering of firm earth or gravel should be left or made on each side to hold the material in place, and should extend to the gutters at the same curvature as the finished road. The foundation should then be rolled until hard and smooth.

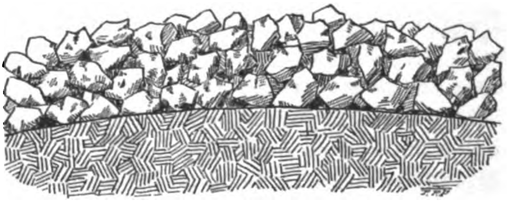

FIG. 43.—First course of stone on a macadam road as it appears when spread ready for rolling.

Upon this bed spread a layer of 5 or 6 inches of broken stone, which stone should be free from any earthy mixture. This layer should be thoroughly rolled until compact and firm (figs. 43, 44, 45). Stone may be hauled from the stone-crusher bins or from the stone piles in ordinary wheelbarrows or farm wagons, and should be distributed broadcast over the surface with shovels, and all inequalities leveled up by the use of rakes. If this method of spreading is employed, grade stakes should be used so as to insure a uniformity of thickness. After the stakes are driven the height of the layer is marked on their sides, and if thought necessary a piece of stout cord is stretched from stake to stake, showing the exact height to which the layer should be spread. Spreading carts (fig. 36) have been recently invented which not only place the stone where it is needed without the use of shovels, but spread it on in layers of any desired thickness and at the same time several inches wider than the carts themselves.

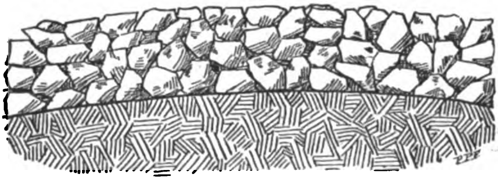
FIG. 44.—First course of stone on a macadam road when partially rolled, showing how the roller packs it.

If the stones have been separated into two or three different sizes the largest size should compose the bottom layer, the next size the second layer, etc. The surface of each course or layer should be thoroughly and repeatedly rolled and sprinkled until it becomes firm, compact, and smooth. The first layer, however, should not be sprinkled as the water is liable to soften the foundation. The rolling ought to be done along the side lines first, gradually working toward the center as the job is being completed. In rolling the last course it is well to begin by rolling first the shoulderings or the side roads if such exist.

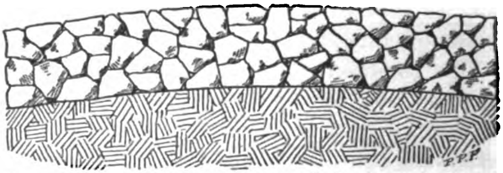
FIG. 45.—Stone on a macadam road firmly wedged and packed together. Small stones, gravel, dirt, or sand if mixed with the stone or spread on the surface before rolling, prevent its being thoroughly wedged and packed.

A coat of three-quarter inch stone and screenings, of sufficient thickness to make a smooth and uniform surface, should compose the last course, and, like the other layers, should be rolled until perfectly firm and smooth. As a final test of perfection, a small stone placed on the surface will be crushed before being driven into the material.

If none of the stones used be larger than will pass through a 2-inch ring they can be spread on in layers as above described without separating them by screens. Water and binding material—stone screenings or good packing gravel—can be added if found necessary for proper consolidation. Earth or clay should never be used for a binding material. Enough water should be sprinkled on to wash in and fill all voids between the broken stones with binding material, and to leave such material damp enough to insure a set.

Rollers.—If a road is built of tough, hard stone, and if the binding material has the same characteristics, a steam roller (fig. 39) is essential for speedy results. A horse roller (fig. 46) may be used to good advantage if the softer varieties of stone are employed. For general purposes, a roller weighing from 8 to 12 tons is all that is necessary. Heavier weights are difficult to handle upon unimproved surfaces unless they be constructed like the one shown in fig. 46, the weight of which can be increased or lightened at will by filling the drum with water or drawing the water out. This roller can be made to weigh as much as 8 tons and, like several other very excellent ones now on the market, is provided with antifriction roller bearings, which lighten the draft considerably.

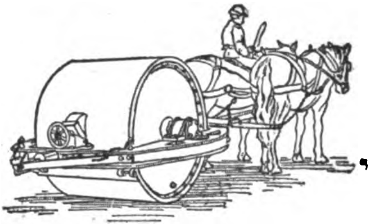

FIG. 46.—The Addison reversible horse roller, the weight of which can be increased by filling the roller with water.

Binding material.—Every stone road, unless properly built with small stones and just enough binding material to fill the voids, presents a honeycombed appearance. In fact, a measure containing 2 cubic feet of broken stone will hold in addition 1 cubic foot of water, and a cubic yard of broken macadam will weigh just about one-half as much as a solid cubic yard of the same kind of stone. Isaac Potter says:

> To insure a solid roadway and to fill the large proportion of voids or interstices between the different pieces of broken stone some finer material must be introduced into the structure of the roadway, and this material is usually called a binder, or by some roadmakers a "filler."
>
> There used to be much contention regarding the use of binding material in the making of a macadam road, but it is now conceded by nearly all practical and experienced roadmakers, both in Europe and America, that the use of a binding material is essential to the proper construction of a good macadam road. It adds to its solidity, insures tightness by closing all of the spaces between the loose irregular stones, and binds together the macadam crust in a way that gives it firmness, elasticity and durability.

Binding material to produce the best results should be equal in hardness and toughness with the road stone; the best results are therefore obtained by using screenings or spalls from the broken stone used. Coarse sand or gravel can sometimes be used with impunity as a binder, but the wisdom of using loam or clay is very much questioned. When the latter material is used for a binder the road is apt to become very dusty in dry weather, and sticky, muddy, and rutty in wet weather.

Telford construction.—The character of the foundation should never take the place of proper drainage. The advisability of underground or subdrainage should always be carefully considered where the road is liable to be attacked from beneath by water. In most cases good subdrains will so dry the foundation out that the macadam construction can be resorted to. Sometimes, however, thorough drainage is difficult or doubtful, and in such cases it is desirable to adopt some heavy construction like the telford; and furthermore the difficulty of procuring perfectly solid and reliable roadbeds in many places is often overcome by the use of this system.

In making a telford road (fig. 47) the surface for the foundation is prepared in the same manner as for a macadam road. A layer of broken stone is then placed on the roadbed from 5 to 8 inches in depth, depending upon the thickness to be given the finished road. As a rule this foundation should form about two-thirds of the total thickness of the material. The stone used for the first layer may vary in thickness from 2 to 4 inches and in length from 8 to 12 inches. The thickness of the upper edges of the stones should not exceed 4 inches. They are set by hand on their broadest edges lengthwise across the road, breaking joints as much as possible. All projecting points are then broken off and the interstices or cracks filled with stone chips, and the whole structure wedged and consolidated into a solid and complete pavement. Upon this pavement layers of broken stones are spread and treated in the same way as for a macadam road.

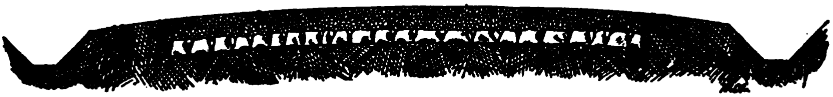

FIG. 47.—Transverse section of telford road with macadam surface.

Stone road maintenance.—Stone roads should be frequently scraped, so as to remove all dust and mud. Nothing destroys a stone road quicker than dust or mud. The hand method of scraping with a hoe is considered best. No matter how carefully adjusted the machinery built for this purpose may be, it is liable to ravel a road by loosening some of the stones. The gutters and surface drains should be kept open, so that all water falling upon the road or on the adjacent ground may promptly flow away. Says Spalding, a road authority:

> If the road metal be of soft material which wears easily, it will require constant supervision and small repairs whenever a rut or depression may appear. Material of this kind binds readily with new material that may be added, and may in this manner frequently be kept in good condition without great difficulty, while if not attended to at once when wear begins to show it will very rapidly increase, to the great detriment of the road. In making repairs by this method, the material is commonly placed a little at a time and compacted by passing vehicles. The material used for this purpose should be the same as that of the road surface and not fine material, which would soon reduce to powder under the loads which come upon it. By careful attention to minute repairs in this manner a surface may be kept in good condition until it wears so thin as to require renewal.
>
> In case the road be of harder material, that will not so readily combine when a thin coating is added, repairs may not be frequent, as the surface will not wear so

rapidly and immediate attention is not so important. It is usually more satisfactory in this case to make more extensive repairs at one time, as a larger quantity of material added at once may be more readily compacted to a uniform surface, the repairs taking the form of an additional layer upon the road.

Where the material of the road surface is very hard and durable, a well-constructed road may wear quite evenly and require hardly any attention, beyond ordinary small repairs, until worn out. It is now usually considered the best practice to leave such a road to itself until it wears very thin, and then renew it by an entirely new layer of broken stone placed in the worn surface and without in any way disturbing that surface.

If a thin layer only of material is to be added at one time, in order that it may unite firmly with the upper layer of the road, it is usually necessary to break the bond of the surface material before placing the new layer, either by picking it up by hand or by a steam roller with short spikes in its surface (fig. 48), if such a machine is at hand. Care should be taken in doing this, however, that only the surface layer be loosened, and that the solidity of the body of the road be not disturbed, as might be the case if the spikes are too long.

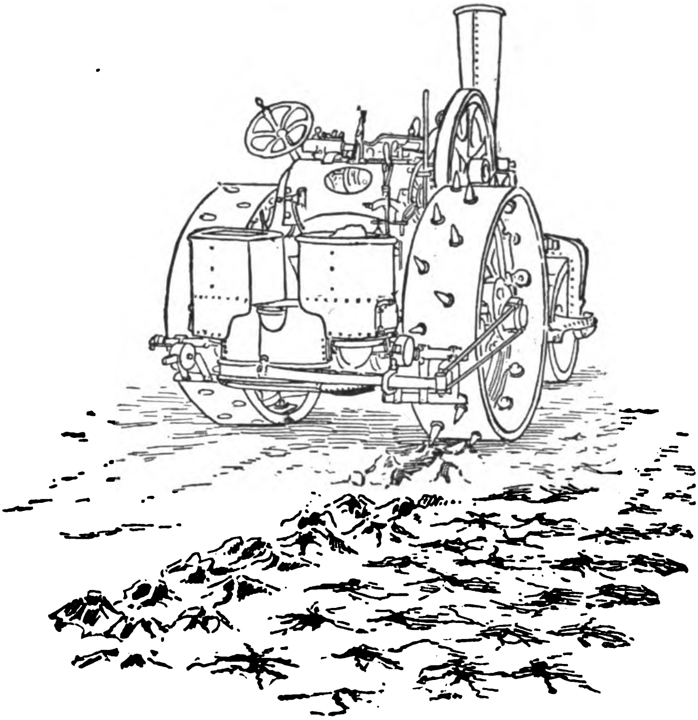

FIG. 48.—Steam roller with spikes in wheel breaking up road surface.

In repairing roads the time-honored custom of waiting until the road has lost its shape or until the surface has become filled with holes or ruts should never be tolerated. Much good material is wasted by spreading a thick coat over such a road and leaving it thus for passing vehicles to consolidate. The material necessary to replace defects in a road should be added when the necessities arise and should be of the best quality and the smallest possible quantity. If properly laid in small patches the inconvenience to traffic will be scarcely perceptible. If such repairs are made in damp weather, as they ought to be, little or no difficulty is experienced in getting a layer of stone to consolidate properly. If mud fills the rut or hole to be repaired, it should be carefully removed before the material is placed.

Wide tires should be used on all heavy vehicles which traverse stone roads (fig. 49). A four or five inch stone or gravel road will last longer without repair when wide tires are used than an eight or ten inch road of the same material on which narrow tires are used.

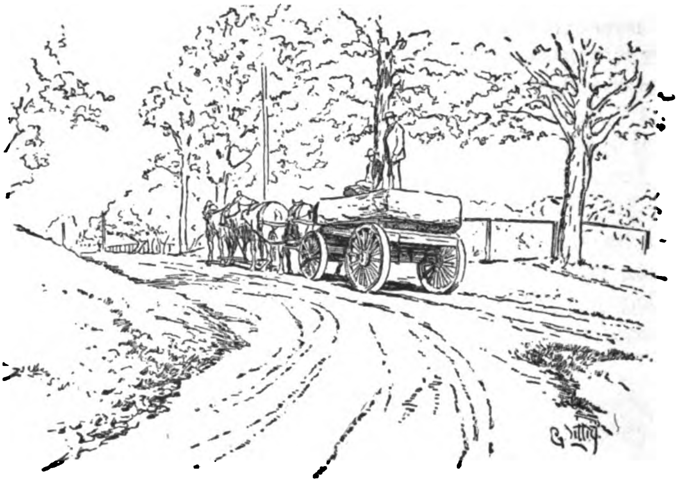

FIG. 49.—Hauling 9 tons of stone on wide-tired wagon over road in Onondaga County, N. Y. (drawn from photograph).

TREES ALONGSIDE OF ROADS.

Not only should brush and weeds be removed from the roadside, but grass should be sown, trees planted, and a side path or walk be prepared for the use of pedestrians, especially women and children, going to and coming from church, school, and places of business and amusement. Country roads can be made far more useful and attractive than they usually are, and this may be secured by the expenditure of only a small amount of labor and money. Although such improvements are not necessary, they make the surroundings attractive and inviting, and add to the value of property and the pleasure of the traveler.

If trees are planted alongside the road they should be far enough back to admit the wind and sun (fig. 30.) Most strong growing trees are apt to extend their roots under the gutters and even beneath the roadway if they are planted too close to the roadside. Even if they be planted at a safe distance those varieties should be selected which send their roots downward rather than horizontally. The most useful and beautiful tree corresponding with these requirements is the chestnut, while certain varieties of the pear, cherry, and mulberry answer the same purpose. Where there is no danger of roots damaging the subdrainage or the substructure of the road some other favorite varieties would be elms, rock maples, horse-chestnuts, beeches, pines, and cedars. Climate, variety of species selected, and good judgment will determine the distance between such trees. Elms should be 30 feet apart, while the less spreading varieties need not be so far. The trunks should be trimmed to a considerable height, so as to admit the sun and air. Fruit trees are planted along the roadsides in Germany and Switzerland, while mulberry trees may be seen along the roads in France, serving the twofold purpose of food for silkworms and shade. If some of our many varieties of useful, fruitful, and beautiful trees were planted along the roads in this country, and if some means could be devised for protecting the product, enough revenue could be derived therefrom to pay for the maintenance of the road along which they throw their grateful shade.

COST OF ROADS.

The improvement of country roads is chiefly an economical question, relating principally to the waste of effort in hauling over bad roads, the saving in money, time, and energy in hauling over good ones, the initial cost of improving roads, and the difference in the cost of maintaining good and bad ones. It is not necessary to enlarge on this subject in order to convince the average reader that good roads reduce the resistance to traffic, and consequently the cost of transportation of products and goods to and from farms and markets is reduced to a minimum.

The initial cost of a road depends upon the cost of materials, labor, machinery, the width and depth to which the material is to be spread on, and the method of construction. All these things vary so much in the different States that it is impossible to name the exact amount for which a mile of a certain kind of road can be built.

The introduction in recent years of improved road-building machinery has enabled the authorities in some of the States to build improved stone and gravel roads quite cheaply. First class single-track stone roads, 9 feet wide, have been built near Canandaigua, N. Y., for $900 to $1,000 per mile. Many excellent gravel roads have been built in New Jersey for $1,000 to $1,300 per mile. The material of which they were constructed was placed on in two layers, each being raked and thoroughly rolled, and the whole mass consolidated to a thickness of 8 inches. In the same State macadam roads have been built for $2,000 to $5,000 per mile, varying in width from 9 to 20 feet and in thickness of material from 4 to 12 inches. Telford roads 14 feet wide and 10 to 12 inches thick have been built in New Jersey for $4,000 to $6,000 per mile. Macadam roads have been built at Bridgeport and Fairfield, Conn., 18 to 20 feet wide, for $3,000 to $5,000 per mile. A telford road 16 feet wide and 12 inches thick was built at Fanwood, N. J., for $9,500 per mile. Macadam roads have been built in Rhode Island, 16 to 20 feet wide, for $4,000 to $5,000 per mile.

Massachusetts roads are costing all the way from $6,000 to $25,000 per mile. A mile of broken stone road, 15 feet wide, costs in the State of Massachusetts about $5,700 per mile, while a mile of the same width and kind of road costs in the State of New Jersey only $4,700. This is due partly to the fact that the topography of Massachusetts is somewhat rougher than that of New Jersey, necessitating the reduction of many steep grades and the building of expensive retaining walls and bridges, and partly to the difference in methods of construction and the difference in prices of materials, labor, etc.

Doubtless the State of New Jersey is building more roads and better roads for less money per mile than any other State in the Union. Their roads are now costing from 20 to 70 cents per square yard. Where the telford construction is used they sometimes cost as much as 73 cents per square yard. The average cost of all classes of the roads of that State during the last season was about 50 cents per square yard. The stone was, as a rule, spread on to a depth of 9 inches, which, after rolling, gave a depth of about 8 inches. At this rate a single-track road 8 feet wide costs about $2,346 per mile, while a double-track road 14 feet wide costs about $4,106 per mile, and one 18 feet wide costs about $5,280 per mile. Where the material is spread on so as to consolidate to a 4-inch layer the 8-foot road will cost about $1,173 per mile, the 14-foot road about $2,053 per mile, while the one 18 feet wide will cost about $2,640 per mile.

The total cost of maintaining roads in good order ranges, on account of varying conditions, between as wide limits almost as the initial cost of construction. Suffice it to say that all money spent on repairing earth roads becomes each year a total loss without materially improving their condition. They are, as a rule, the most expensive roads that can be used, while on the other hand stone roads, if properly constructed of good material and kept in perfect condition, are the most satisfactory, the cheapest, and most economical roads that can be constructed.

CONCLUSION.

The road that will best suit the needs of the farmer, in the first place, must not be too costly; and, in the second place, must be of the very best kind, for farmers should be able to do their heavy hauling over them when their fields are too wet to work and their teams would otherwise be idle.

The best road for the farmer, all things being considered, is a solid, well-built stone road, so narrow as to be only a single track, but having a firm earth road on one or both sides. Where the traffic is not very extensive the purposes of good roads are better served by narrow tracks than by wide ones, while many of the objectionable features of wide tracks are removed, the initial cost of construction is cut down one-half or more, and the charges for repair reduced in proportion.

FARMERS' BULLETINS.

The following is a list of the Farmers' Bulletins available for distribution, showing the number, title, and size in pages of each. Copies will be sent to any address on application to Senators, Representatives, and Delegates in Congress, or to the Secretary of Agriculture, Washington, D. C.: The missing numbers have been discontinued, being superseded by later bulletins.

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22. The Feeding of Farm Animals. Pp. 32.
24. Hog Cholera and Swine Plague. Pp. 16.
25. Peanuts: Culture and Uses. Pp. 24.
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47. Insects Affecting the Cotton Plant. Pp. 32.
48. The Manuring of Cotton. Pp. 16.
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51. Standard Varieties of Chickens. Pp. 48.
52. The Sugar Beet. Pp. 48.
53. How to Grow Mushrooms. Pp. 20.
54. Some Common Birds. Pp. 40.
55. The Dairy Herd. Pp. 24.
56. Experiment Station Work—I. Pp. 31.
57. Butter Making on the Farm. Pp. 16.
58. The Soy Bean as a Forage Crop. Pp. 24.
59. Bee Keeping. Pp. 32.
60. Methods of Curing Tobacco. Pp. 16.
61. Asparagus Culture. Pp. 40.
62. Marketing Farm Produce. Pp. 28.
63. Care of Milk on the Farm. Pp. 40.
64. Ducks and Geese. Pp. 48.
65. Experiment Station Work—II. Pp. 32.
66. Meadows and Pastures. Pp. 28.
67. Forestry for Farmers. Pp. 48.
68. The Black Rot of the Cabbage. Pp. 22.
69. Experiment Station Work—III. Pp. 32.
70. Insect Enemies of the Grape. Pp. 23.
71. Essentials in Beef Production. Pp. 24.
72. Cattle Ranges of the Southwest. Pp. 32.
73. Experiment Station Work—IV. Pp. 32.
74. Milk as Food. Pp. 39.
75. The Grain Smuts. Pp. 20.
76. Tomato Growing. Pp. 30.
77. The Liming of Soils. Pp. 19.
78. Experiment Station Work—V. Pp. 32.
79. Experiment Station Work—VI. Pp. 28.
80. The Peach Twig-borer. Pp. 16.
81. Corn Culture in the South. Pp. 24.
82. The Culture of Tobacco. Pp. 24.
83. Tobacco Soils. Pp. 23.
84. Experiment Station Work—VII. Pp. 32.
85. Fish as Food. Pp. 30.
86. Thirty Poisonous Plants. Pp. 32.
87. Experiment Station Work—VIII. Pp. 32.
88. Alkali Lands. Pp. 23.
89. Cowpeas. Pp. 16.
91. Potato Diseases and Treatment. Pp. 12.
92. Experiment Station Work—IX. Pp. 30.
93. Sugar as Food. Pp. 27.
94. The Vegetable Garden. Pp. 24.
95. Good Roads for Farmers. Pp. 47.
96. Raising Sheep for Mutton. Pp. 48.
97. Experiment Station Work—X. Pp. 32.
98. Suggestions to Southern Farmers. Pp. 48.
99. Insect Enemies of Shade Trees. Pp. 30.
100. Hog Raising in the South. Pp. 40.
101. Millets. Pp. 28.
102. Southern Forage Plants. Pp. 48.
103. Experiment Station Work—XI. Pp. 32.
104. Notes on Frost. Pp. 24.
105. Experiment Station Work—XII. Pp. 32.
106. Breeds of Dairy Cattle. Pp. 48.
107. Experiment Station Work—XIII. Pp. 32.
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112. Bread and Bread Making. Pp. 39.
113. The Apple and How to Grow It. Pp. 32.
114. Experiment Station Work—XIV. Pp. 28.
115. Hop Culture in California. Pp. 27.
116. Irrigation in Fruit Growing. Pp. 48.
117. Sheep, Hogs, and Horses in the Northwest. Pp. 28.
118. Grape Growing in the South. Pp. 32.
119. Experiment Station Work—XV. Pp. 31.
120. Insects Affecting Tobacco. Pp. 32.
121. Beans, Peas, and other Legumes as Food. Pp. 32.
122. Experiment Station Work—XVI. Pp. 32.
123. Red Clover Seed: Information for Purchasers. Pp. 11.
124. Experiment Station Work—XVII. Pp. 32.
125. Protection of Food Products from Injurious Temperatures. Pp. 26.
126. Practical Suggestions for Farm Buildings. Pp. 48.
127. Important Insecticides. Pp. 42.
128. Eggs and Their Uses as Food. Pp. 32.
129. Sweet Potatoes. Pp. 40.
130. The Mexican Cotton Boll Weevil. Pp. 30.
131. Household Test for Detection of Oleomargarine and Renovated Butter. Pp. 11.
132. Insect Enemies of Growing Wheat. Pp. 40.
133. Experiment Station Work—XVIII. Pp. 32.
134. Tree Planting in Rural School Grounds. Pp. 38.
135. Sorghum Sirup Manufacture. Pp. 40.
136. Earth Roads. Pp. 24.
137. The Angora Goat. Pp. 48.
138. Irrigation in Field and Garden. Pp. 40.
139. Emmer: A Grain for the Semiarid Regions. Pp. 16.
140. Pineapple Growing. Pp. 48.
141. Poultry Raising on the Farm. Pp. 16.
142. The Nutritive and Economic Value of Food. Pp. 48.
143. The Conformation of Beef and Dairy Cattle. Pp. 44.
144. Experiment Station Work—XIX. Pp. 32.
145. Carbon Bisulphid as an Insecticide. Pp. 28.
146. Insecticides and Fungicides. Pp. 16.
147. Winter Forage Crops for the South. Pp. 36.
148. Celery Culture. Pp. 32.
149. Experiment Station Work—XX.
150. Clearing New Land.

U. S. DEPARTMENT OF AGRICULTURE.

FARMERS' BULLETIN No. 96.

Raising Sheep for Mutton.

BY

CHARLES F. CURTISS,
Director of the Iowa Agricultural Experiment Station.

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LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF ANIMAL INDUSTRY,
Washington, D. C., April 25, 1899.

SIR: I have the honor to transmit herewith for publication as a Farmers' Bulletin an article on Raising Sheep for Mutton, submitted by the author, Prof. C. F. Curtiss, director of the Iowa Agricultural Experiment Station, in accordance with your instructions.

Very respectfully,

D. E. SALMON, *Chief.*

Hon. JAMES WILSON,
Secretary of Agriculture.

CONTENTS.

Page.
Introduction 3
Increasing demand for good mutton 4
Sheep production as a feature of American agriculture 4
  Mutton the primary consideration 5
Investigations at the experiment stations (illustrated) 6
  Plan of experiments 6
Cost of producing mutton 22
Relative cost of producing mutton and beef 28
Feed consumed per 1,000 pounds live weight 28
Advantage of finishing at an early age 28
Lambs preferred in the markets 29
Method of cutting mutton (illustrated) 32
Range-lamb feeding (illustrated) 34
Dipping 38
The feeding of range and pure-bred lambs compared (illustrated) 38
The value of improved blood 40
What constitutes a good sheep 41
Essentials of a good fleece 42
General notes on sheep feeding 43
  The self-feeder 44
  Regular feeding essential 45
  Feeding three times a day 46
  Requisites of a good shepherd 46
  When is a lamb fat? 47

RAISING SHEEP FOR MUTTON.

INTRODUCTION.

Sheep are associated with man in the earliest records of the human race. They were first used only for milk and later the skins were used for clothing. Nearly a century and a half have elapsed since Robert Bakewell of Dishley, Loughborough, England, began the first systematic and intelligent improvement of mutton sheep. Prior to that time wool had been the primary consideration in sheep raising.

Spain, the home of the Merino, at one time controlled the wool markets of the world, and in the early management of the Spanish Merino the ewes were so small that it was common to kill half the lambs in order that those remaining might go to two ewes. The fleece was practically the only consideration in the sheep reared in that country, and this has been the distinguishing characteristic of the Merino breed until within the present decade. As late as 1892 Mr. J. H. McKibbon, of Albion, Iowa, exhibited a yearling American Merino at the Iowa Sheep Breeders' shearing meeting that yielded a 15-pound fleece from a 54-pound carcass; and even in England, the home of the mutton sheep, we find the following supplication publicly recorded in an early day:

May God lend his helping aid
To Keswick and its woolen trade.

Bakewell's work marks the beginning of a new era in sheep raising in Great Britain. His achievements in the practical and scientific improvement of live stock and the consequent increased value and profit in farm animals entitle him to take rank with the greatest benefactors of humanity. Bakewell's contemporaries credit him as being a man of such analytical and systematic methods, such force of intellect and creative genius, that he would have been eminent in any field of labor or undertaking. The problems connected with live-stock production are even more intricate at the present time and the conditions in agriculture more exacting. Good animals never come by chance or haphazard methods; they have been the product of a high degree of intelligence, skill, and intellectual ability. This field will always be worthy of the best minds and highest talent the world affords. The mutton sheep has been slow in invading America. Here, as in Europe, the wool-producing Merino held almost undisputed sway for many years. Fabulous prices prevailed for sheep having no adaptation whatever to anything except wool production.

INCREASING DEMAND FOR GOOD MUTTON.

The American people have been characterized as a nation of pork eaters and pork producers, with little or no appreciation of good mutton. However this may have been in the past, the conditions are rapidly changing. Perhaps the recent depression in the price of wool is largely accountable for the readjustment and changed condition; at any rate, there is a constantly increasing demand for good mutton in the United States. The Chicago market alone in 1894 took nearly a million more mutton sheep than during any previous year, and the receipts during 1898 are the largest on record.[1] Notwithstanding the impetus of increased demand and good prices and the rapidly increasing population, the number of sheep in the United States is considerably lower than in former years. The average of the numbers on hand each year, January 1, from 1891 to 1895 inclusive, was 44,448,885, and the average of the number on hand January 1, from 1896 to 1899 inclusive, was 37,972,212.[2] During the former period two Canadian provinces, Quebec and Ontario, sent to our markets 1,524,046 head of sheep, valued at nearly $5,000,000. This importation of mutton sheep from Canada still continues, notwithstanding the fact that a heavy duty is imposed, and that Canadian mutton is also made on higher-priced feeds and lands than prevail in our own country. During the past year the number of sheep imported at Buffalo alone was 175,697, valued at $574,882. We have also been importing twenty-five to thirty million dollars' worth of wool annually during recent years.

SHEEP PRODUCTION AS A FEATURE OF AMERICAN AGRICULTURE.

The production of prime mutton for American and European markets is rapidly becoming a permanently established industry of vast proportions in the United States. Our rich lands and abundant feeds are well suited to the economical production of superior mutton, and it has been clearly demonstrated that mutton sheep properly selected can grow a large part, if not all, of the wool demanded for American manufacturing. The erroneous impression has prevailed that sheep are only suited to inferior lands. No greater error can be imagined. While it is true that sheep are well adapted to scanty vegetation and capable of profitably grazing semiarid lands, they also render as large returns for a liberal ration of good feeds as any domestic animal, with the possible exception of the hog. The high-priced agricultural lands of Great Britain sustain 680 sheep per thousand acres, and Scotland in 1893 had even as high as 1,380 sheep per thousand acres of agricultural lands.[3] The leading agricultural States of the Union have not to exceed 25 sheep per thousand acres of land.

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[1] Live Stock Report, January 5, 1899.

[2] Statistics of the United States Department of Agriculture.

[3] Sheep, Breeds and Management, by John Wrightson, London.

The seven States constituting the corn-belt area of the United States produced over a billion bushels of corn and 237,000,000 bushels of oats in 1896.[1] The annual production of these crops ranges nearly as great; in 1897 the aggregate corn product was about the same, and the oat crop amounted to 372,000,000 bushels. A large part of this product is obliged to seek a market abroad, and there is not always a profitable cash market for these surplus grains. This has been particularly true during the recent years of low-priced corn, but during all that time there has been a possibility of realizing returns equivalent to 40 or 50 cents a bushel for corn fed to good mutton sheep. There are also some other considerations worth noting. The sale of $1,000 worth of corn at present prices takes from the soil producing the crop about $300 worth of fertility; that is, it takes materials for which the owner of the land would have to pay this amount if he were obliged to purchase commercial fertilizers at the rates usually prevailing in the market, but the same amount of corn can be converted into good mutton and sold at an advanced price and it will take from the land not to exceed $50 worth of fertility, or if sold in the form of wool it will not take from the land over $2 or $3 worth of fertility. It will be incomparably better for American farming and for our system of agriculture to convert the surplus grain products into prime meats to the extent at least of supplying home demands, and then find foreign markets for the condensed and high-priced meat products rather than export the corn and other grains as such.

During the recent years of contraction, as indicated by the figures already quoted, the market for good mutton has been continually expanding, and the experience of every successful sheep raiser in any section of the United States emphatically refutes the doctrine that any of our lands are too valuable for mutton production.

MUTTON THE PRIMARY CONSIDERATION.

Notwithstanding this apparent contraction of our flocks the sheep industry has made substantial progress. It has been established on a more permanent and lasting basis by making mutton the primary consideration and wool incidental, instead of the reverse, as has generally been the case heretofore. On this basis, sheep raising will return a satisfactory profit one year with another, independent of the price of wool, or nearly so, as it has been clearly demonstrated that it does not cost any more, if even as much, to produce a pound of mutton from good mutton sheep under average farm conditions than to produce a pound of beef, when the wool is left entirely out of consideration; and the wool always has some value; it seldom goes so low that well-bred mutton sheep will not yield a fleece worth from 75 cents to $1.50.

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[1] Statistics of the United States Department of Agriculture.

Large numbers of sheep have been fattened annually in the grain-producing States the past few years, and many important truths and fundamental facts pertaining to this industry have been established. These all tend to place sheep raising on a more permanent basis. Practical feeders and farmers have found that there is no more profitable outlet for surplus grain products, particularly after the country has suffered from the ravages of hog cholera, than in mutton production.

INVESTIGATIONS AT THE EXPERIMENT STATIONS.

Many careful and scientific investigations have been conducted at the experiment stations, which also shed new light on the problems of sheep feeding. Some of these are extracted for these pages on account of the lessons of general interest they contain.

PLAN OF EXPERIMENTS.

The investigation of this subject was taken up at the Iowa Experiment Station when the depression in the sheep business had reached its lowest point. The primary object was to determine the relative economy of production and value of mutton and wool compared with other farm products, and incidentally to derive information concerning the demands of the market for these products and the adaptation of some of the leading breeds to meet the market requirements. The experiment planned for this purpose consisted in using ten carefully selected representatives each of ten of the leading breeds of sheep to be used in a feeding experiment covering a period of about one hundred days, taking the lambs at weaning time, or soon afterwards, and finishing them for market in prime condition, carefully determining the cost of producing a pound of mutton from each breed and the average weight of fleece, and the value of both mutton and wool on the market. This was followed by a thorough and exhaustive slaughter and block test giving the weight and value of various parts of the carcasses, and a photograph of the leading cuts on the block. The investigation covered a period of two years in order to insure greater accuracy, and the results were found to be substantially uniform in the two trials.

The breeds included Southdown, Shropshire, Oxford, Suffolk, Lincoln, Leicester, Cotswold, Dorset, Merino, Merino and Shropshire cross, and Shropshire ewes. The first experiment covered a feeding period of ninety days and the second one hundred and six days. Three representative lambs from each lot were photographed near the close of each experiment. The photographs were taken in such position as to show front quartering, side, and rear quarter views of each breed, and reproduced in groups. The reproductions are quite free from exaggerations and show the lambs just as they were taken by the camera, the object in reproducing them being to combine the three views in one illustration. The characteristics and quality of the several breeds are accurately represented by the figures appearing in the following pages, and the record and summary of feeding made by the representatives of each breed are given in condensed form.

In the second experiment the Rambouillets were used instead of the National Delaine Merinos, in order to afford a comparison of another family of Merinos; and the Shropshire-Merino crossbreds were also omitted from the second experiment and a bunch of pure-bred Shropshire ewe lambs similar to the Shropshire wethers was included for the purpose of comparing the feeding and mutton qualities of ewes and wethers of the same breed.

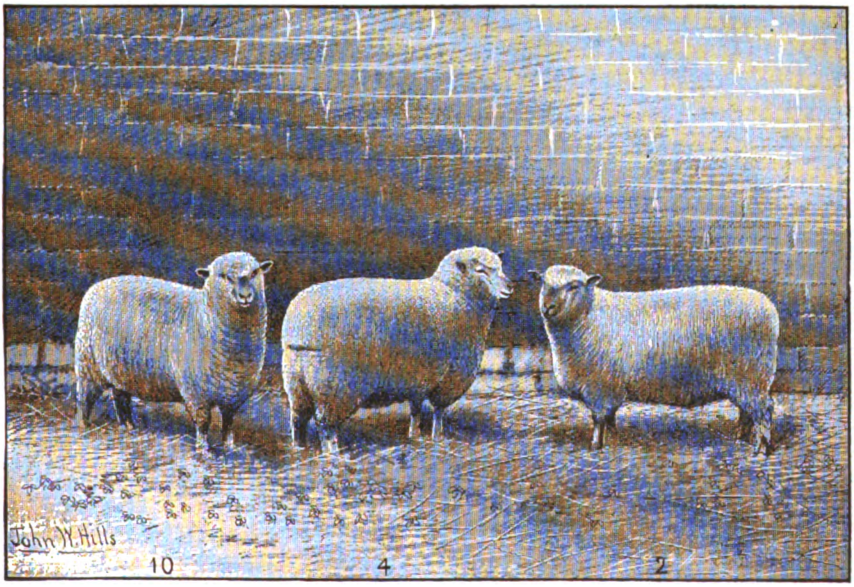

FIG. 1.—Three representative Southdowns.

Record of breed.

Data relating to the experiments.	First experiment.	Second experiment.
Average age of the lambs .... days..	374	289
Average weight (March 31, shorn) .... pounds..	125	*a* 102.4
Time occupied in feeding experiments .... days..	90	106
Average gain per day during the experiment........ pound..	.45	.35
Average dry matter fed per pound of gain .... pounds..	7.38	9.89
Average cost of feed per pound of gain .... cents..	2.93	3.12
Selling price on Chicago market per cwt .... dollars..	4.75	5.75
Average yield of dressed mutton........ per cent..	55.4	55.26
Average weight of fleece........ pounds..	6.75	4.59
Average age of fleece........ days..	366	289
Average value of fleece........ cents..	75	64
Average yearly weight of fleece........ pounds..	6.75	5.79
Average yearly value of fleece........ cents..	75	81
Average weight of wool per 1,000 pounds, live weight .... pounds..	54	44.8
Average value of wool per 1,000 pounds, live weight........ dollars..	6.03	6.27
Value of wool per pound in natural condition........ cents..	11½	14
Average shrinkage in scouring........ per cent..	54¼	....
Value of wool per pound in scoured condition........ cents..	26	....

a Sold January 1.

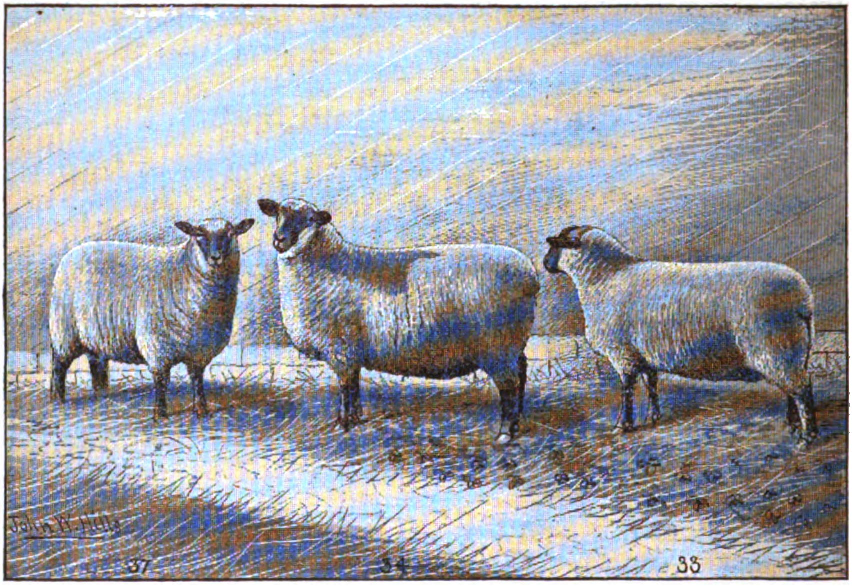

FIG. 4.—Three representative Suffolks.

Record of breed.

Data relating to the experiments.	First experiment.	Second experiment.
Average age of lambs ....days..	394	285
Average weight (March 31, shorn).......................pounds..	159	*a* 134.4
Time occupied in feeding experiments......................days..	90	106
Average gain per day during the experiment..............pound..	.55	.40
Average dry matter fed per pound of gain ....pounds..	7.40	10.36
Average cost of feed per pound of gain.....................cents..	2.95	3.44
Selling price on Chicago market per cwt ....dollars..	4.25	5.00
Average yield of dressed mutton.........................per cent..	53.6	52.54
Average weight of fleece..................................pounds..	7.65	5.20
Average age of fleece..days..	383	285
Average value of fleece......................................cents..	86	75
Average yearly weight of fleece..........................pounds..	7.29	6.64
Average yearly value of fleece ....cents..	82	95
Average weight of wool per 1,000 pounds of live weight...pounds..	48.26	40.24
Average value of wool per 1,000 pounds of live weight ....dollars..	5.45	5.80
Value of wool per pound in natural condition..............cents..	11	14½
Average shrinkage in scouring..........................per cent..	54¼	....
Value of wool per pound in scoured condition..............cents..	24	....

a Sold January 1.

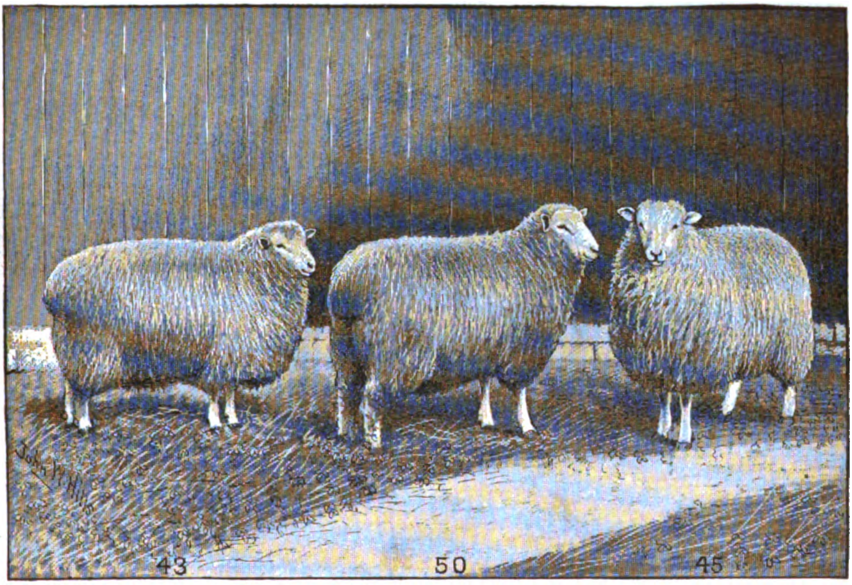

FIG. 5.—Three representative Lincolns.

Record of breed.

Data relating to the experiments.	First experiment.	Second experiment.
Average age of lambs..days..	345	291
Average weight (March 31, shorn)......................pounds..	158	a 143.5
Time occupied in feeding experiments......................days..	90	106
Average gain per day during the experiment..............pound..	.55	.46
Average dry matter fed per pound of gain ....pounds..	7.29	9.1
Average cost of feed per pound of gain.....................cents..	2.89	2.86
Selling price on the Chicago market per cwt..............dollars..	4.50	5.25
Average yield of dressed mutton........................per cent..	55.7	51.08
Average weight of fleece.................................pounds..	12.85	10.4
Average age of fleece......................................days..	332	291
Average value of fleece..................................dollars..	1.79	1.56
Average yearly weight of fleece.......................pounds..	14.13	13.03
Average yearly value of fleece..........................dollars..	1.96	1.95
Average weight of wool per 1,000 pounds of live weight..pounds..	81.48	78.13
Average value of wool per 1,000 pounds of live weight....dollars..	11.37	11.72
Value of wool per pound in natural condition..............cents..	13¼	15
Average shrinkage in scouring..........................per cent..	40	....
Value of wool per pound in scoured condition..............cents..	23	....

a Sold January 1.

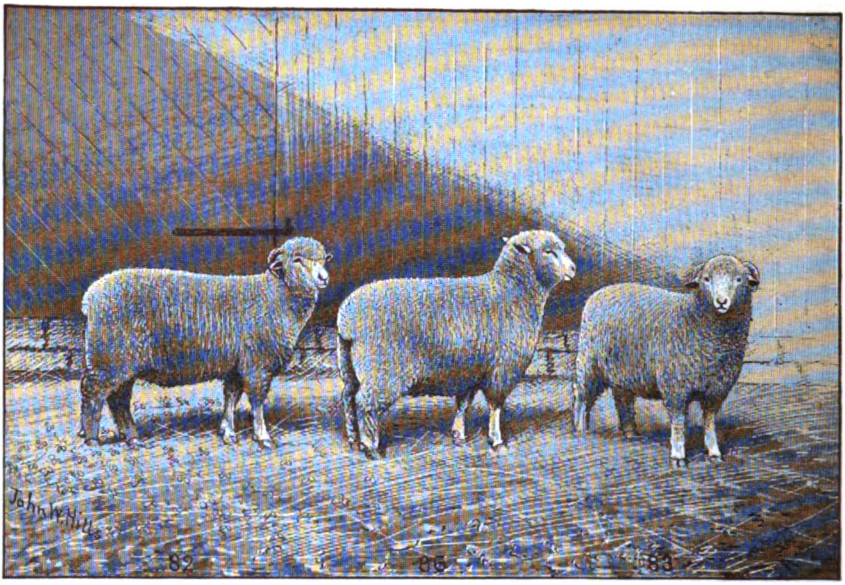

FIG. 10.—Three representative Rambouillets (French-Merinos).

Record of breed.

Data relating to the experiment.	Second experiment.
Average age of lambs ....days..	255
Average weight ....pounds..	*a* 113.3
Time occupied in feeding experiment ....days..	106
Average gain per day during the experiment ....pound .	.37
Average dry matter fed per pound of gain ....pounds..	10.29
Average cost of feed per pound of gain........cents..	2.91
Selling price on Chicago market per cwt........dollars..	5.00
Average yield of dressed mutton........per cent..	49.57
Average weight of fleece ....pounds..	6.60
Average age of fleece ....days..	255
Average value of fleece........cents..	73
Average yearly weight of fleece........pounds..	9.42
Average yearly value of fleece ....dollars..	1.04
Average weight of wool per 1,000 pounds of live weight........pounds..	61.85
Average value of wool per 1,000 pounds of live weight ....dollars..	6.84
Value of wool per pound in natural condition........ cents..	11

a Sold January 1.

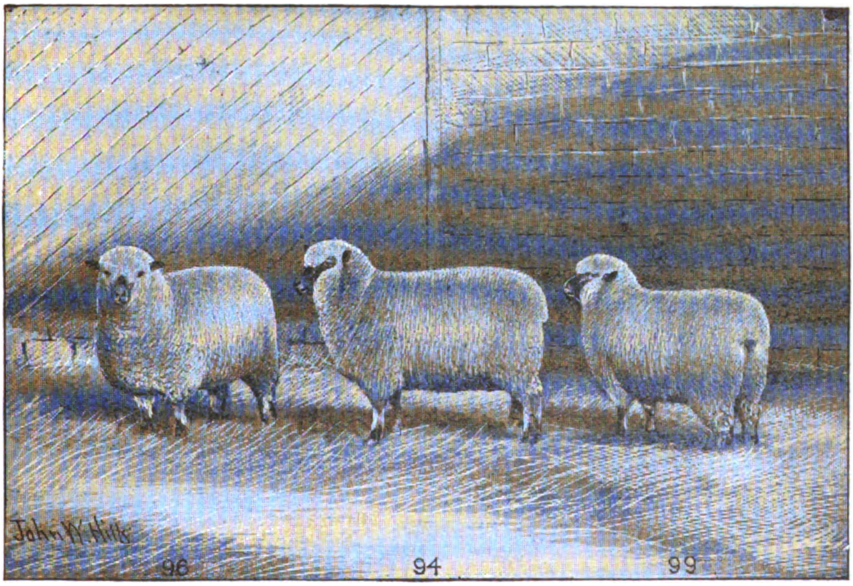

FIG. 11.—Three representative Shropshire ewes.

Record of breed.

Data relating to the experiment.	Second experiment.
Average age of lambs.....days..	255
Average weight.....pounds..	*a* 100
Time occupied in feeding experiment.....days..	106
Average gain per day during the experiment.....pound..	.31
Average dry matter fed per pound of gain.....pounds..	10.30
Average cost of feed per pound of gain.....cents..	3.18
Selling price on Chicago market per cwt.....dollars..	5.65
Average yield of dressed mutton.....per cent..	54.55

a Sold January 1.

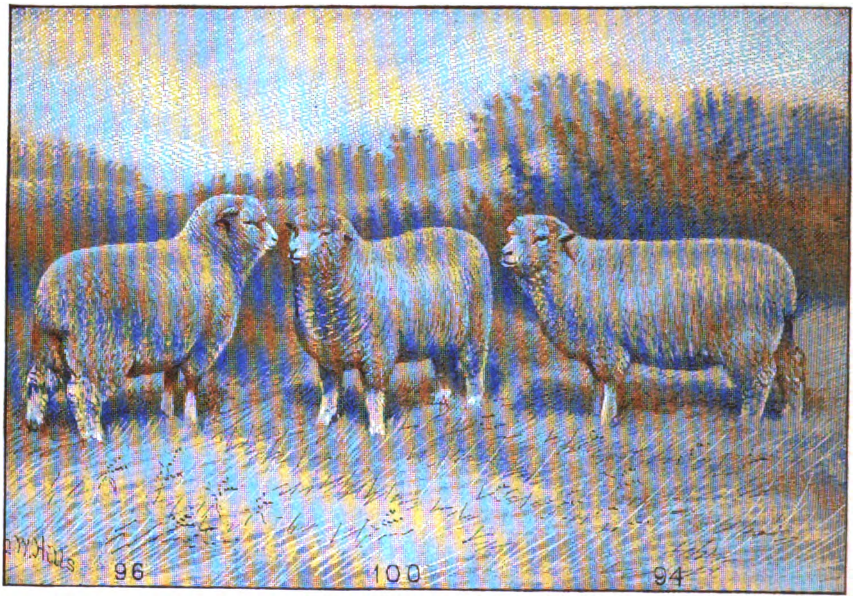

FIG. 12.—Three representative Shropshire-Merino crossbreds.

Record of breed.

Data relating to the experiment.	First experiment.
Average age of the lambs ....days..	346
Average weight (March 31, shorn) ....pounds..	111
Time occupied in feeding experiment ....days..	90
Average gain per day during the experiment ....pound..	.41
Average dry matter fed per pound of gain ....pounds..	7.02
Average cost of feed per pound of gain ....cents..	2.82
Selling price on Chicago market per cwt ....dollars..	4.50
Average yield of dressed mutton ....per cent..	53.7
Average weight of fleece ....pounds..	7.5
Average age of fleece ....days..	334
Average value of fleece ....cents..	90
Average yearly weight of fleece ....pounds..	8.2
Average yearly value of fleece ....cents..	98
Average weight of wool per 1,000 pounds live weight ....pounds..	67.87
Average value of wool per 1,000 pounds live weight ....dollars..	8.15
Value of wool per pound in natural condition ....cents..	11¾
Average shrinkage in scouring ....per cent..	53
Value of wool per pound in scoured condition ....cents..	25

In computing the cost of gain the feeds used were estimated at the following prices, based on the commercial values prevailing in the local market during this investigation:

Feed.		First experiment.	Second experiment.
Bran	per cwt.	$0.40	$0.35
Oats	do	.40	.35
Shelled corn	do	.28½	.20
Oil meal	do	.90	.90
Hay	do	.28	.20
Roots	do	.05	.05
Cabbage	do	....	.10

The feeding record presented in the following pages gives the total amount of feed consumed by each breed during both experiments and the gains and cost of making a pound of mutton. The number of pounds of dry matter required for a pound of gain are also shown. This determination is made in order to afford a uniform basis for comparison, as all farm feeds, no matter how completely air dried, contain more or less water, ranging from about 11 per cent in corn and oats to as high as 90 per cent in mangels and turnips. The records of the first and second experiments are presented separately, and the average results of both experiments are included with the record of the second in order to furnish more complete data for comparison.

It will be seen that the ration varies considerably at the beginning and end of the experiments owing to the fact that the lambs were on a light feed of grain and a heavy feed of hay at the outset, and the grain ration given at the beginning consisted principally of bran and oats, and the shelled corn and oil meal were added as the feeding advanced. This is a necessary precaution in getting lambs or sheep on to feed, as they do not take to a concentrated grain ration readily at the beginning.

Complete feeding record for all breeds in first experiment.

		Shelled corn.	Oats.	Bran.	Oil meal.	Turnips.	Mangels.	Clover hay.	Pea hay.	Timothy hay.	Total gain.	Gain per head daily (average).	Total dry matter.	Pounds of dry matter per pound of gain (average).	Total cost of feed.	Cost of feed per pound of gain (average).
		Lbs.	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*			*Cents.*
10 Southdown lambs..	January.......	237	238	47	47	99	170	348	124	12	135	.43	950.7	7.04	$3.73	2.8
	February......	254	254	32	63	....	261	460	40	....	125	.43	993.5	7.95	3.97	3.18
	March.........	260	261	32	64	....	204	557	....	....	145.5	.48	1,046	7.21	4.14	2.48
Southdown totals and averages..		751	753	111	174	99	635	1,365	164	12	405.5	.45	2,990.2	7.38	11.84	2.93
10 Shropshire lambs..	January.......	249	247	50	49	112	167	328	124	12	123	.39	957.7	7.78	3.78	3.7
	February......	273	273	34	68	....	269	455	40	....	136	.46	1,030.4	7.57	4.14	3.4
	March.........	286	287	36	72	....	234	564	....	....	170.5	.56	1,093.6	6.43	4.45	2.61
Shropshire totals and averages..		808	807	120	189	112	670	1,347	164	12	429.5	.48	3,081.7	7.18	12.37	2.88
10 Oxford lambs......	January.......	288	288	57	56	115	193	419	124	14	167	.54	1,123.5	6.72	4.42	2.64
	February......	311	312	39	78	....	299	548	40	....	131	.45	1,194.8	9.12	4.79	3.66
	March.........	332	333	41	82	....	293	646	....	....	174.5	.58	1,284.2	7.38	5.10	2.92
Oxford totals and averages......		931	933	137	216	115	985	1,613	164	14	472.5	.52	3,602.5	7.40	14.31	3.03
10 Suffolk lambs......	January.......	294	295	59	59	121	186	439	124	14	181	.58	1,144.1	6.32	4.55	2.51
	February......	321	321	40	80	....	299	561	40	....	143	.49	1,225.4	8.56	4.91	3.43
	March.........	335	335	42	84	....	294	654	....	....	172.5	.58	1,298.3	7.55	5.20	3.01
Suffolk totals and averages......		950	951	141	223	121	779	1,654	164	14	496.5	.55	3,667.8	7.40	14.66	2.95
10 Lincoln lambs.....	January.......	280	282	57	56	115	193	445	124	16	142	.46	1,134.8	7.99	4.45	3.13
	February......	310	310	39	77	....	299	571	40	....	155	.53	1,210.7	7.81	4.83	3.12
	March.........	338	338	42	84	....	294	644	....	....	202.5	.68	1,294.1	6.40	5.19	2.55
Lincoln totals and averages,....		928	930	138	217	115	786	1,660	164	16	499.5	.55	3,639.6	7.29	14.47	2.89
9 Leicester lambs....	January.......	219	219	50	48	105	171	348	124	12	88	.31	921.9	10.47	3.63	4.12
	February......	274	274	34	69	....	271	508	40	....	160	.61	1,078.2	6.74	4.30	2.70
	March.........	300	300	38	76	....	364	587	....	....	176	.65	1,176.3	6.68	4.62	2.62
Liecester totals and averages ...		793	793	122	193	105	806	1,443	164	12	424	.52	3,176.4	7.49	12.55	2.93

10 Cotswold lambs	January	280	282	57	56	127	181	447	123	16	155	.50	1,135.2	7.32	4.45	2.87
	February	310	310	39	77	....	299	572	40	....	183	.63	1,211.5	6.02	4.84	2.64
	March	338	338	42	84	....	294	646	....	....	218.5	.72	1,286.8	5.90	5.20	2.38
Cotswold totals and averages		928	930	138	217	127	774	1,665	163	16	556.5	.62	3,633.5	6.53	14.49	2.60
10 Dorset lambs	January	272	272	53	52	123	184	440	124	15	128	.43	1,106.1	8.64	4.32	3.37
	February	286	287	36	72	....	299	558	40	....	130	.45	1,150.5	8.85	4.30	3.31
	March	301	302	38	76	....	364	572	....	....	178	.56	1,166.2	6.55	4.69	2.64
Dorset totals and averages		859	861	127	200	123	847	1,570	164	15	436	.48	3,422.8	7.85	13.31	3.05
10 Merino lambs	January	243	242	47	48	108	170	285	118	10	102	.33	900.8	8.83	3.58	3.51
	February	236	236	29	59	....	261	284	37	....	104	.36	803.4	7.72	3.30	3.17
	March	201	200	25	50	....	204	307	....	....	52	.17	708.3	13.62	2.88	5.54
Merino totals and averages		680	678	101	157	108	635	876	155	10	258	.29	2,412.5	9.35	9.76	3.78
10 crossbred lambs	January	243	243	48	48	120	158	295	121	12	132	.43	915.1	6.93	3.36	2.75
	February	239	240	30	60	....	261	293	32	....	107	.37	814.6	7.61	3.34	3.12
	March	231	231	29	58	....	204	417	....	....	131	.43	866.7	6.61	3.49	2.66
Crossbred totals and averages		713	714	107	166	120	623	1,005	153	12	370	.41	2,596.4	7.02	10.46	2.82
10 range lambs	January	184	181	36	36	78	119	280	121	11	78	.25	764.4	9.80	2.97	3.38
	February	191	191	24	48	....	174	345	38	....	131	.45	751.4	5.73	3.00	2.29
	March	197	198	24	49	....	136	388	....	....	124	.41	762.1	6.14	3.05	2.46
Range totals and averages		572	570	84	133	78	429	1,013	159	11	333	.37	2,277.9	6.84	9.02	2.71
Grand total, all breeds		8,913	8,920	1,326	2,085	1,223	7,769	15.211	1,778	144	4,678	.48	34,501.5	7.37	137.24	2.93
Grand total, first seven breeds		6,089	6,097	907	1,429	794	5,135	10,747	1,147	96	3,281	.53	23,791.9	7.25	94.69	2.88

A full allowance of hay may be given with safety. Bran or other comparatively bulky feeds are well suited to starting sheep on feed, and for the same reason oats is safer than corn.

During the preliminary feeding period, 1 pound of grain is a sufficient allowance for 10 lambs daily; following this the grain ration may be increased to one-quarter of a pound per head, but it should not exceed one-half a pound for native-bred lambs at the end of thirty days. Range lambs will not eat more than one-third to one-half this amount with safety. Hay feeding alone without any grain is sometimes practiced for the first thirty or sixty days in regions where alfalfa is abundant and of good quality, and quite satisfactory gains are thus obtained. It is a serious mistake to attempt to put lambs or sheep onto heavy grain rations suddenly, and one that not infrequently causes serious loss and permanent injury.

During the latter part of this experiment the oats, shelled corn, and oil meal were increased and the lambs crowded to their full capacity. Some of the larger breeds consumed as much as 2¼ pounds of grain per head daily.

COST OF PRODUCING MUTTON.

The summary of the first experiment with the lambs shows that—

One hundred and nine head consumed 34,501 pounds of feed (total dry matter) in ninety days and made a gain of 4,678 pounds.

Seven special mutton breeds consumed 23,792 pounds of feed and gained 3,281 pounds.

This gain is at the rate of 1 pound increase in live weight for each 7.37 pounds of feed (dry matter) by all breeds tested, and 1 pound for each 7.25 by seven special mutton breeds.

Complete feeding record for all breeds in second experiment, and summary of both experiments.

		Shelled corn.	Oats.	Bran.	Oil meal.	Hay.	Cabbage.	Green clover.	Roots.	Total gain.	Gain per head daily (average).	Total dry matter.	Pounds of dry matter per pound of gain (average).	Total cost of feed.	Cost of feed per pound of gain (average)
		Lbs.	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*			*Cents.*
10 Southdown lambs	Sept. 16 to 30	64.39	65.92	32.19	....	259	239	172	....	55	0.36	436.69	7.94	$1.27	2.30
	October	240.40	240.40	60.20	34.90	585	582	....	....	127	.41	1,064.06	8.37	3.69	2.98
	November	248	248	62	43.50	540	294.50	....	42.50	89	.29	1,046.12	11.75	3.56	4.00
	December	288.25	257.80	49.20	49	533	....	....	263	107	.34	1,193.37	11.12	3.28	3.07
Southdown totals and averages		841.04	812.12	203.59	127.40	1,917	1,115.50	172	305.50	378	.35	3,740.24	9.89	11.80	3.12
10 Southdown lambs, first experiment		751	753	111	174	1,541	....	....	784	405.5	.45	2,990.20	7.38	11.84	2.93
Summary for the breed, both experiments		1,592.04	1,565.12	314.59	301.40	3,458	....	....	1,039.50	783.5	.40	6,730.44	8.59	23.64	3.02
9 Shropshire lambs	Sept. 16 to 30	63.27	64.82	31.63	....	273.60	24.21	207	....	59	.43	400.09	6.77	1.08	1.83
	October	227.18	227.18	56.79	33.16	596.90	579.60	....	....	123	.44	1,045.98	8.71	3.44	2.80
	November	236.68	236.68	59.17	41.42	556	302.50	....	79.50	82	.30	1,026.10	12.51	3.33	4.06
	December	281.06	251.36	47.97	38.04	555	....	....	274.50	80	.28	1,056.86	13.21	3.20	3.99
Shropshire totals and averages		808.19	780.04	195.56	112.62	1,981.50	1,124.20	207	354	344	.36	3,529.08	10.26	11.05	3.21
10 Shropshire lambs, first experiment		808	807	120	189	1,523	....	....	782	429.5	.48	3,081.70	7.18	12.87	2.88
Summary for the breed, both experiments		1,616.19	1,587.04	315.56	301.62	3,504.50	....	....	1,136	773.5	.41	6,611.15	8.54	23.42	3.02
9 Oxford lambs	Sept. 16 to 30	69.65	71.30	34.82	....	315.90	269	243	....	55	.40	476.40	8.66	1.46	2.67
	October	255.08	255.08	63.77	37.19	693.50	559	....	....	148	.53	1,190.40	8.04	3.89	2.73
	November	256.28	256.28	64.07	44.85	659	314	....	87.50	80	.28	1,156.62	14.45	3.71	4.63
	December	260.12	290.57	50.80	39.43	657	....	....	276	104	.37	1,166.33	11.21	3.51	3.38
Oxford totals and averages		841.13	873.32	213.46	121.47	2.324.40	1,142	243	363.50	387	.40	3,989.75	10.31	12.57	3.22
10 Oxford lambs, first experiment		931	933	137	216	1,791	....	....	1,100	472.5	.52	3,602.50	7.40	14.31	3.03
Summary for the breed, both experiments		1,772.13	1,806.32	350.46	337.47	4,115.40	....	....	1,463.50	859.5	.46	7,592.25	8.83	26.88	3.13

Complete feeding record for all breeds in second experiment, and summary of both experiments—Continued.

		Shelled corn.	Oats.	Bran.	Oil meal	Hay.	Cabbage.	Green clover.	Roots.	Total gain.	Gain per head daily (average).	Total dry matter.	Pounds of dry matter per pound of gain (average).	Total cost of feed.	Cost of feed per pound of gain (average).
		Lbs.	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*			*Cents.*
9 Suffolk lambs	Sept. 16 to 30	69.51	71.28	34.75		301.50	269.10	243		63	0.46	508.61	8.05	1.98	3.15
	October	253	253	63.25	36.82	707.40	648.90			132	.47	1,201.91	9.10	4.00	3.03
	November	247.16	247.16	61.79	43.25	641.70	127.80		79.65	105	.38	1,106.73	10.44	3.77	3.59
	December	294.55	263.10	50.05	39.75	648.90			335.70	85	.30	1,171.38	13.78	3.50	4.12
Suffolk totals and averages		864.22	834.54	209.84	119.82	2,299.50	1,045.80	243	415.35	385	.40	3,988.63	10.36	13.25	3.44
10 Suffolk lambs, first experiment		950	951	141	223	1,832			900	496.5	.55	3,667.80	7.40	14.66	2.95
Summary for the breed, both experiments		1,814.22	1,785.54	350.84	342.82	4,131.50			1,315.35	881.5	.47	7,645.42	8.67	27.91	3.16
9 Lincoln lambs	Sept. 16 to 30	69.34	71.64	34.91		275.40	269.10	243		73	.54	486.80	6.67	1.39	1.90
	October	252.13	252.13	62.88	36.88	696.70	653.90			160	.57	1,191.22	7.44	3.98	2.48
	November	264.12	264.12	66.03	46.22	659	316		83.50	104	.37	1,175.70	11.30	3.77	3.62
	December	305.11	273.16	52.31	41.41	655			275.50	107	.38	1,192.48	11.05	3.57	3.33
Lincoln totals and averages		891.20	861.05	216.13	124.51	2,286.10	1,239	243	259	444	.46	4,046.20	9.11	12.71	2.86
10 Lincoln lambs, first experiment		928	930	138	217	1,840			901	499.5	.55	3,639.60	7.29	14.47	2.89
Summary for the breed, both experiments		1,819.20	1,791.05	354.13	341.51	4,126.10			1,160	943.5	.50	7,681.89	8.03	27.18	2.88
9 Leicester lambs	Sept. 16 to 30	69.40	71.17	34.70		305.10	269.10	243		64	.47	511.46	7	1.45	2.26
	October	240.24	240.24	60.06	34.81	695.70	650.70			163	.58	1,190	7.30	3.88	2.31
	November	259.20	259.20	64.80	45.36	554.70	316.40		61.20	93	.34	1,070.34	11.50	3.52	3.78
	December	273	303.95	52.27	41.48	664			274	105	.37	1,198.99	11.41	3.63	3.45
Leicester totals and averages		841.84	874.56	211.83	121.65	2,219.50	1,236.20	243	335.20	425	.44	3,970.79	9.34	12.48	2.93
9 Leicester lambs, first experiment		793	793	122	193	1,619			911	424	.52	3,176.40	7.49	12.55	2.93
Summary for the breed both experiments		1,634.84	1,667.56	333.83	314.65	3,838.50			1,246.20	849	.47	7,147.23	8.42	25.03	2.98
9 Cotswold lambs	Sept. 16 to 30	69.46	71.21	34.72		247.90	269.10	243		85	.62	462.06	5.43	1.33	1.56
	October	259.32	259.32	64.72	32.45	698.90	652.50			177	.63	1,203.43	6.79	4.00	2.21
	November	261.20	261.20	65.30	45.71	659	316		88.45	96	.35	1,167.59	12.16	3.75	3.90
	December	273	304.95	52.27	41.38	654			273	121	.43	1,229.99	10.74	3.62	2.99
Cotswold totals and averages		862.98	896.68	217.01	119.54	2,259.80	1,237.60	243	361.45	479	.50	4,063.07	8.48	12.70	2.65

10 Cotswold lambs, first experiment		928	930	138	217	1,844	....	....	901	556.5	.62	3,633.50	6.53	14.49	2.60
Summary for the breed, both experiments		1,790.98	1,826.68	355.01	336.54	4,103.80	....	....	1,262.45	1,035.5	.55	7,695.57	7.45	27.19	2.62
9 Dorset lambs	Sept. 16 to 30	69.75	71.47	34.87	....	313.50	210.50	239.40	....	70	.52	513.86	7.34	1.41	2.00
	October	286.49	286.49	64.12	18.76	713	659	....	....	144	.51	1,253.77	8.70	4.05	2.81
	November	250.72	250.72	62.68	43.87	659	223	....	88.50	90	.22	1,110.07	12.33	3.66	4.05
	December	257.56	287.36	49.40	39.11	667	....	....	263	110	.39	1,217.70	11.07	3.49	3.17
Dorset totals and averages		864.52	896.04	211.07	101.74	2,352.50	1,092.50	239.40	351.50	414	.43	4,095.40	9.89	12.61	3.04
10 Dorset lambs, first experiment		859	861	127	200	1,749	....	....	970	436	.48	3,422.80	7.85	13.31	3.05
Summary for the breed, both experiments		1,723.52	1,757.04	338.07	301.74	4,101.50	....	....	1,321.50	850	.45	7,518.02	8.84	25.92	3.05
8 Rambouillet lambs	Sept. 16 to 30	57.21	58.57	28.60	....	246.08	161.79	186.67	....	57	.47	408.19	7.16	1.12	1.96
	October	212.40	212.40	23.10	38.01	538.33	522.89	....	....	122	.49	939.32	7.69	2.94	2.41
	November	203.48	203.48	50.87	35.61	538	256	....	79	74	.30	932.51	12.60	2.63	3.55
	December	203	227.05	38.73	30.72	534	....	....	229.50	59	.23	929.57	15.75	2.59	4.39
Rambouillet totals and averages		676.09	701.50	141.30	104.34	1,856.41	940.68	186.67	308.50	312	.37	3,209.59	10.29	9.28	2.91
10 Delaine Merino lambs, first experiment		680	678	101	157	1,041	....	....	743	258	.29	2,412.50	9.35	9.76	3.78
Summary for the Merinos, both experiments		1,356.09	1,379.50	242.30	261.34	2,897.41	....	....	1,051.50	570	.32	5,622.09	9.86	19.04	3.34
Grand total, all breeds, second experiment		7,491.21	7,529.85	1,819.79	1,053.09	19,496.71	10,173.48	2,020.07	2,895.35	3,568	.415	34,632.70	9.67	108.45	3.04
Grand total, first seven breeds, second experiment		5,950.60	5,932.31	1,467.42	847.01	15,287.80	8,140.30	1,594	2,314.35	2,842	.418	27,227.71	9.58	86.56	3.04
Grand total, first seven breeds, first experiment		6,089	6,097	907	1,429	12,990	....	....	5,929	3,281	.53	23,791.90	7.25	94.69	2.88
Grand total, first seven breeds, both experiments		12,039.60	12,029.31	2,374.42	2,276.01	28,277.80	....	....	8,243.35	6,123	.467	51,019.61	8.33	181.25	2.96
Grand total, all breeds, both experiments		16,404.21	16,449.85	1,951.79	3,138.09	36,629.71	....	....	11,887.35	8,246	.448	69,134.20	8.38	245.69	2.97
10 Shropshire ewes, second experiment	Sept. 16 to 30	59.38	60.91	29.69	....	257	223	194	....	72	.48	429.52	5.96	1.21	1.69
	October	216.09	216.09	54.02	31.15	588	583	....	....	102	.32	1,014.50	9.94	3.42	3.34
	November	212	212	53	37.10	539	293.50	....	81.50	77	.25	956.15	12.41	3.09	4.03
	December	206.28	232.28	39.77	31.49	557	....	....	254	82	.26	1,031.07	12.57	2.89	3.52
Shropshire ewes, totals and averages		693.75	721.28	176.48	99.74	1,941	1,099.50	194	335.50	333	.31	3,431.24	10.30	10.61	3.18

The record of the second experiment, as will be seen by reference to the summary, is hardly as uniform or as good as that of the first; the difference was attributed mainly to the interference caused by the stomach worms which seriously infested nearly all of the lambs at the beginning and to some extent throughout the experiment. They were unusually severe throughout nearly all of the sheep-raising States that year, more so than they have been at any time since, though they are annually the source of considerable loss to sheep raisers in the farming sections.

In the first experiment the increase in live weight was made at the cost of 2.93 cents per pound for all breeds, and 2.88 cents per pound for the seven special mutton breeds. This calculation allows the prevailing market price for grains, but does not take the fleece, the labor, or the value of the manure into account. In the second experiment the cost was increased for all breeds to 3.04 cents, owing to the difficulties previously mentioned; but notwithstanding this the increase in live weight was made at considerably less than the market price of mutton in both cases, as will be seen by the following record of sales:

Weights and selling price per hundredweight of the lambs.

Breed.	First experiment		Second experiment.	
	Weight.	Price.	Weight.	Price.
	Pounds.		*Pounds.*	
Southdown	125	$4.75	102.4	$5.75
Shropshire	135	4.62½	126	5.60
Oxford	155	4.50	136.7	5.40
Suffolk	159	4.25	134.4	5.00
Lincoln	158	4.50	143.5	5.25
Leicester	167	4.50	133	5.25
Cotswold	161	4.50	138.4	5.25
Dorset	138	3.75	128.3	5 50
Merino	99	4.25	113.3	5.00
Shropshire-Merino crossbred	111	4.50	....	....
Shropshire ewes	....	....	100	5.65

The price of grain feeds during this experiment was somewhat lower than is common in many of the grain-producing States, although the cost of producing mutton at average prices of grain will seldom be found above the market value, even when the value of the fleece is not taken into account. In the first experiment the lambs were shorn before they were marketed, and the following table presents a record of the average weights and values of the fleeces from each breed:

Weights and value of the fleeces.

Breed.	Date of shearing.	Average age of fleece.	Average weight of fleece.	Value per pound in natural condition.	Per cent shrinkage in scouring.	Value per pound in scoured condition.	Value of fleece per head.
		Days.		*Cents.*		*Cents.*	
10 Southdown lambs	Mar. 23	366	6.75	11⅛	54¼	26	*a* $0.75
10 Shropshire lambs.........	Mar. 23	363	8.75	11	56¼	25	.98
10 Oxford lambs.............	Mar. 21-23	365	10.95	12¾	47	24	1.44
10 Suffolk lambs.............	Mar. 21	383	7.65	11	54¼	24	.86
10 Lincoln lambs............	Mar. 17-20	332	12.85	13¾	40	23	1.79
9 Leicester lambs	Mar. 18-20	348	11.55	14¾	38½	24	1.76
10 Cotswold lambs	Mar. 17-20	334	12.65	13	43½	23	1.06
10 Dorset lambs.............	Mar. 18-20	355	6.825	10¾	55¼	24	.77
10 Merino lambs	Mar. 18-20	359	9.9	9¾	67½	30	1.00
10 crossbred lambs.........	Mar. 18-20	334	7.5	11¾	53	25	.90
10 range lambs.............	Mar. 20-21	321	5.125	12⅛	48	24	.67
10 Shropshire yearlings	Mar. 21	313	10.5	12¼	49	24	1.34

a The values in this column are obtained by dividing the value of wool from each breed by the number of sheep. The Chicago weights varied a little from the home weights taken at date of shearing.

The lambs were considerably younger in the second experiment and the fleeces were correspondingly lighter, as will be seen by reference to the summary following the illustrations. The estimated value of the wool on the lambs in the second experiment was reported by a firm who are leading wool commission merchants of Chicago, as follows:

DEAR SIR: At your request we carefully inspected the ten different lots of your sheep at the Union Stock Yards, this city, with a view of ascertaining as nearly as possible to-day's market value of the wool. While it is a little out of our line to examine wool on the sheep's back, we exercised our very best judgment and give you below the result of our careful inspection.

We place the value on to-day's market of the Southdown wool, which we class in a general way as medium, at 14 cents.

The Lincoln wool would be classed as common combing, and worth 15 cents.

The Leicester wool we also classed as common combing, value 15 cents.

The Shropshire, low medium, value 14 cents.

The Oxford, low medium and quarter-blood, value 14½ cents.

The Suffolk, medium, value 14½ cents.

The Shropshire ewe lambs, value 14½ cents.

The Dorset, medium, value 14 cents.

The Cotswold, combing, value 15 cents.

The French merino, value 11 cents.

Without doubt, if the wool had been shorn and all passed over the grading board in our lofts, some individual fleeces from the different lots would be worth more or less than the prices given above. We however tried to make the average as near right as possible.

Trusting the same will meet with your approval, and hoping that the experiments which have been conducted by you will prove to be a benefit to the sheep growers of the West, we beg to remain,

Yours, truly,

——— ———.

This lot of lambs was not shorn before marketing, but was examined at the yards by experts, and the weight of fleece obtained by deducting from the weight of the pelts the estimated weight of the skins based on the slaughter test of the same breeds in the previous experiment. This doubtless was approximately accurate.

RELATIVE COST OF PRODUCING MUTTON AND BEEF.

The gains made in each experiment were, all things considered, quite satisfactory, and compare favorably with results in beef production. A carload of choice Hereford cattle coming 2 years old was fattened during the same winter that the first lamb experiment was conducted. These were finished and put on the market at the same time as the lambs. The record made by these cattle was fairly representative of the best work in cattle feeding at that age, and it was found that they required an average of 8.9 pounds of dry matter for each pound of increase in live weight.

A summary of results published by the Ohio Experiment Station,[1] compiled from experiments conducted with a large number of cattle at various stations in the United States, gives the average number of pounds dry matter per pound of increase in live weight at 10.24, and a recently published report of the work of Lawes and Gilbert[2] gives 11 pounds for cattle and 9 pounds for sheep. The better results obtained at the Iowa station in this experiment are doubtless largely due to the fact that younger animals were used. The conditions for comparison appear fair, however, as both the cattle and sheep were finished at a comparatively early age. This indicates that a pound of mutton can be made on lambs at less expenditure for feed than is required to produce a pound of beef on cattle at the ordinary age of finishing for market.

FEED CONSUMED PER 1,000 POUNDS LIVE WEIGHT.

It is sometimes asserted that cattle and sheep require the same amount of feed per thousand pounds of live weight. This statement seems not to be well founded. In the experiments referred to the cattle consumed 19.6 pounds of dry matter per thousand pounds of live weight, against an average of 29.07 by the sheep. Both sheep and cattle were on full feed. The sheep made a daily gain of 3.73 pounds per thousand pounds live weight, and the cattle 2.14. In summing up this comparison, we find that while the sheep ate 48 per cent more than the cattle, they also gained nearly 75 per cent more.

ADVANTAGE OF FINISHING AT AN EARLY AGE.

With older sheep a larger amount of feed is required in proportion to increase in live weight. This was quite clearly demonstrated in the experiment conducted by the Iowa Stations[3] in which the costs of producing gain on pure-bred Shropshire wethers and lambs under the same conditions and on the same ration were compared:

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[1] Bulletin No. 60, Ohio Station, by Thorne and Hickman.

[2] Farmers' Gazette, Dublin, Ireland.

[3] Bulletin No. 33, Iowa Station.

Feeding of lambs and yearlings compared.

Breed.	Month.	Mixed grain.	Roots.	Hay.	Total gain.	Average gain per head daily.	Total dry matter.	Pounds of dry matter per pound of gain (average).	Total cost of feed.	Cost of feed per pound of gain (average).
		Pounds.	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*			*Cents.*
10 Shropshire lambs..........	Jan...	595	279	464	123	.39	957.7	7.78	$3.78	3.7
	Feb..	648	269	495	136	.46	1,030.4	7.57	4.14	3.4
	Mar..	681	234	564	170.5	.56	1,093.6	6.43	4.45	2.61
Totals and averages..	....	1,924	782	1,523	429.5	.48	3,081.7	7.18	12.37	2.88
5 Shropshire yearlings...........	Jan...	403	186	250	59	.34	594.3	10.07	2.38	4
	Feb...	362	174	216	38	.26	527.4	13.88	2.16	5.7
	Mar..	340	136	233	52.5	.35	516.6	9.93	2.10	4
Totals and averages..	....	1,105	496	699	149.5	.33	1,638.3	11	6.64	4.44

It will be seen that it cost 56 per cent more to produce gain on yearlings than on lambs of the same breed; perhaps this difference is somewhat greater than would ordinarily occur on account of the wethers being somewhat fatter at the beginning of the experiment than the lambs, although the comparison from month to month shows a wide difference in each case. It always costs proportionately less to make gains on young animals than on older ones.

LAMBS PREFERRED IN THE MARKETS.

The market also favors the younger animal. In this case the yearlings sold for $4.25 per hundred, live weight, and the lambs for $4.75 on the same market, a difference of 10 per cent in favor of the lambs. On this account it is generally more profitable to finish sheep for market under 1 year of age than to hold them longer unless an abundance of cheap feed is available, as is the case where lands are cheap or free range accessible.

In the slaughter test the lambs dressed the following percentages of net carcass to live weight:

Percentages of yield of dressed mutton.

Breed.	First experiment.	Second experiment.
Southdown	55.4	55.26
Shropshire	56.3	52.88
Oxford	55.2	50.08
Suffolk	53.6	52.54
Lincoln	55.7	51.08
Leicester	57.8	51.87
Cotswold	54.9	53.57
Dorset	52.6	54.11
Merino	51.8	49.57
Crossbred	53.7	....

The Shropshire yearlings fed in comparison with the Shropshire lambs dressed 62.3 per cent.

The details of the slaughter test of the lambs in the first experiment made by Swift & Co., of Chicago, are shown in the following tables, giving the weight and percentage of each part:

*Slaughter test.**

Part.	10 Southdown lambs.		10 Shropshire lambs.		10 Oxford lambs.		10 Suffolk lambs.		10 Lincoln lambs.		9 Leicester lambs.	
	Weight.	*Per cent.*	*Weight.*	*Per cent.*	*Weight.*	*Per cent.*	*Weight.*	*Per cent.*	*Weight.*	*Per cent.*	*Weight.*	*Per cent.*
Mutton	651	59.24	696	58.78	800	60.24	800	58.36	808	59.50	815	62.88
Pelts	100	9.09	104.5	8.83	131	9.86	121	8.82	148.5	10.94	118	9.11
Blood	42.5	3.88	48	4.05	54.5	4.11	58	4.23	57.5	4.23	53.5	4.12
Heads	29.5	2.68	29.5	2.49	38	2.86	39	2.84	35.5	2.61	32.5	2.51
Horns												
Tongues	4.5	.42	4	.34	5.5	.41	5.5	.41	5	.37	4.5	.35
Feet	6	.54	6.5	.55	8.5	.64	8	.59	8	.58	7.5	.59
Caul fat	38.25	3.48	44.5	3.76	40	3.01	46.5	3.39	43	3.09	41	3.16
Bed tallow	3.5	.32	2.5	.22	4	.30	4	.29	3.5	.25	3.5	.27
Paunches, empty	32.5	2.95	35.5	2.99	41.5	3.13	44	3.21	39.5	2.91	38	2.93
Paunches, waste	65.5	5.98	82.5	6.97	63	4.76	99.5	7.26	78	5.39	55	4.25
Paunches, fat	3.5	.32	3.5	.30	3.5	.26	4	.28	4	.29	3.5	.28
Intestines, empty	18.5	1.68	18.5	1.56	21	1.58	22	1.61	21	1.54	18	1.39
Intestines, waste	40.5	3.64	41.5	3.51	47.5	3.58	49.5	3.61	45.5	3.35	44.5	3.43
Intestines, fat	14.5	1.32	15.5	1.31	15	1.13	19	1.39	14.5	1.07	14.5	1.11
Livers	20.5	1.86	23.5	1.98	21	1.58	18	1.31	21	1.54	21.5	1.66
Hearts	4.5	.42	5	.42	5.5	.41	5.5	.41	5.5	.42	6	.47
Lungs and windpipes	19	1.73	16.5	1.39	22.5	1.69	21	1.53	19	1.50	14.5	1.11
Heart fat	1.5	.13	2	.17	1.5	.11	2	.14	2	.14	1.5	.11
Pluck fat	3.5	.32	4.5	.38	4.5	.34	4.5	.32	4	.28	3.5	.27
Total	1,099	100	1,184	100	1,328	100	1,371	100	1,358	100	1,296	100

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* The percentages of dressed mutton given in this table do not correspond with those given on the preceding page, but Swift & Co. explain that the variation is due to the fact that the slaughter-test percentages are computed from the warm weights, while the others are from cold weights.

Slaughter test—Continued.

Part.	10 Cotswold lambs.		10 Dorset lambs.		10 Merino lambs.		10 Crossbred lambs.		10 Range lambs.		5 Shropshire yearlings.	
	Weight.	*Per cent.*	*Weight.*	*Per cent.*	*Weight.*	*Per cent.*	*Weight.*	*Per cent.*	*Weight.*	*Per cent.*	*Weight.*	*Per cent.*
Mutton	795	58.89	666	57.27	496	56.11	554	57.35	516	56.16	560	66.10
Pelts	141	10.44	93	8	92	10.41	108.5	11.23	102	11.09	70	8.26
Blood	55.5	4.11	49	4.21	40	4.53	42	4.35	39.5	4.29	32	3.76
Heads	37	2.74	37.75	3.25	33.5	3.79	26.5	2.74	25.5	2.77	19	2.24
Horns	....	....	25	2.15	7	.79	....	....	....	....	....	....
Tongues	5	.37	4.75	.41	4.5	.51	4	.41	3.5	.38	2.5	.29
Feet	8.5	.63	7.5	.65	5.5	.62	6	.62	6	.66	3	.35
Caul fat	41	3.04	25.5	2.19	38	4.30	42.5	4.40	39	4.24	36	4.25
Bed tallow	3	.22	3	.26	2.5	.28	2.5	.26	2.5	.27	2	.23
Paunches, empty	43.5	3.22	39	3.35	26.5	3	27	2.80	23	2.50	19.5	2.30
Paunches, waste	85.5	6.33	78	6./1	36.5	4.13	43	4.45	55.5	6.09	31	3.66
Paunches, fat	3.5	.26	2.5	.21	3	.34	3	.31	3.5	.38	3	.35
Intestines, empty	21	1.56	21	1.80	15	1.70	25.5	2.64	15.5	1.68	11.5	1.36
Intestines, waste	47.5	3.52	46.5	4	30.5	3.45	25.5	2.64	39.5	4.29	16	2.08
Intestines, fat	13	.97	13.5	1.16	16	1.81	15.5	1.60	11.5	1.25	12	1.41
Livers	22	1.63	18.5	1.59	15.5	1.75	17	1.76	14	1.52	13.5	1.53
Hearts	5.5	.41	5	.43	4	.45	4.5	.47	4	.42	4	.47
Lungs and windpipes	16.5	1.22	17.5	1.50	14	1.58	12.5	1.29	14	1.52	7	.82
Heart fat	1.5	.11	1.5	.13	2.25	.25	1.5	.16	1.5	.16	2.5	.27
Pluck fat	4	.29	8.5	.73	1.75	.20	5.5	.57	3	.33	2.5	.27
Total	1,350	100	1,163	100	884	100	966	100	919	100	847	100

METHOD OF CUTTING MUTTON.

The method of cutting a carcass is shown in the accompanying diagram, and the prices given for the several cuts are based upon the Chicago market for prime mutton at the time of this experiment.

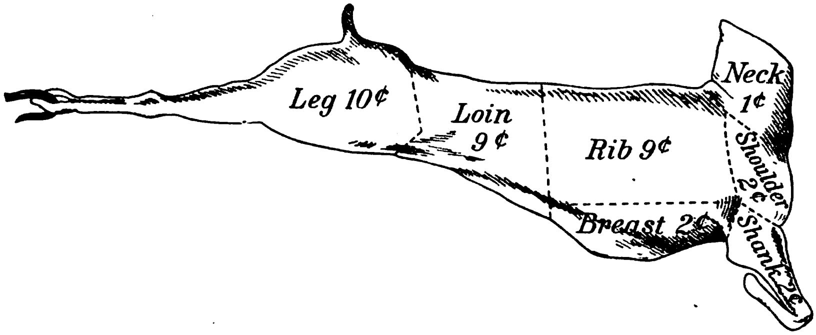

FIG. 13.—Diagram showing cuts of mutton.

The weights and values given below for the several cuts are the averages made by the seven special mutton breeds in the first experiment.

Leg, 22.2 pounds, at 10 cents	$2.22
Loin, 17.5 pounds, at 9 cents	1.57
Rib, 14.5 pounds, at 9 cents	1.30
Chuck,[1] 19.8 pounds, at 1¾ cents	.34
	5.43

It will be seen that the leg, loin, and rib are the high-priced cuts that determine the value of a carcass of mutton. An animal that fails in one of these, fails essentially to meet the requirements of the market for high-priced mutton. This is particularly true of the leg cut; and plump, well-filled legs are indispensable in prime lambs.

The following illustrations present good front and back views of a carcass selected as a model at the Union Stock Yards, Chicago. It shows a remarkably well-filled leg, back, rib, and loin; the flesh being even and thick at all points, and on cutting it was found to be of superior quality throughout. This is the profitable type of carcass to the killer and consumer as it contains the highest proportion of choice meat and the minimum of cheap product and offal. It was taken from a 95-pound Southdown.

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[1] The chuck consists of the breast, shank, shoulder, and neck.

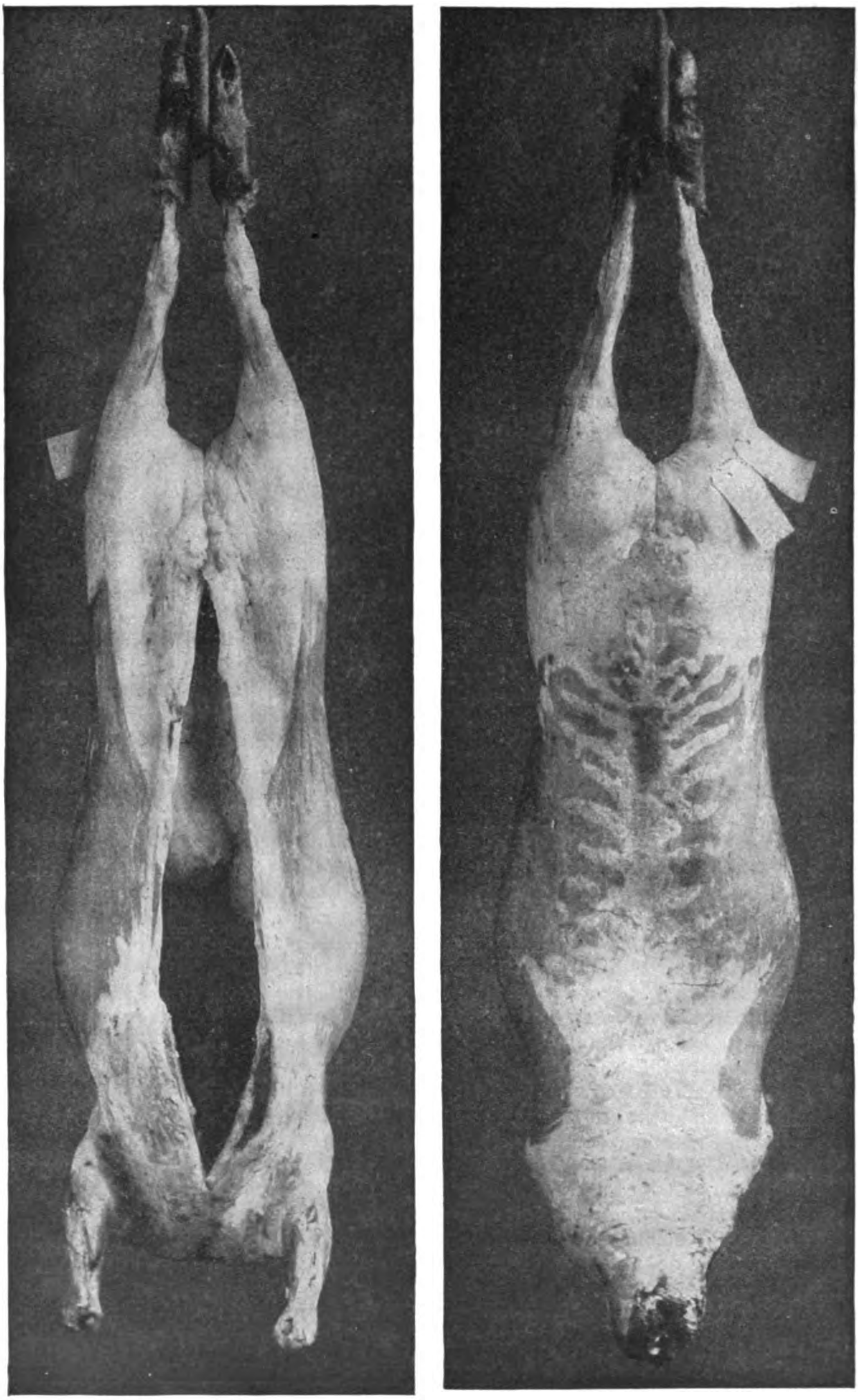

Fig. 14—(*a*) Southdown carcass—front view; (*b*) Southdown carcass—back view.

RANGE LAMB FEEDING.

The territory west of the one hundredth meridian, known as the Range, is rapidly becoming the great breeding ground for sheep. Already this locality is producing about one-half of the total number of sheep in the United States. During the past few years sheep have been rapidly crowding the cattle off of the northern portion of this Range territory, and it is quite generally recognized that the range-cattle industry is gradually disappearing, except in the southern section. While this territory is favorable to the grazing of stock in large numbers, the natural conditions will not permit of the production of sufficient feed to properly fatten and finish the stock grown there. The finishing can only be done by drawing on the surplus grain crops of the upper Mississippi Valley States. This has been largely practiced during the past few years, owing to the shortage of good feeding stock in the farming sections, the surplus of grain products, and prevailing low prices. On this account there is a general interest in the character and feeding value of the sheep raised on the Range. These sheep are classified by Prof. W. W. Cooke as follows:[1]

Old Mexico Sheep.—These sheep are the direct descendants of the original Spanish-Merinos, brought over two hundred years ago by the Spaniards to Old Mexico. They have been bred with scarcely any outcross and are very distinctly marked. They have long legs; a long thin body, not very deep; small, rather long neck, and a long thin head, carried high. The wool is fine and thin. To the eye they appear almost worthless as mutton sheep, and of still less value for wool. Their good points are that they are hardy, excellent travelers, will keep in good condition on the poorest and driest of ranges, are fairly prolific, and can be herded in bunches of almost any size. They fatten easily, though never looking plump and fat, like the Northern sheep. When they reach the Chicago market, if in good condition, they outsell all other sheep, for they shrink very little in dressing, the meat has an excellent flavor, and the hide is so thin, firm, and soft as to command the highest price. A well-fattened bunch of Mexican lambs will weigh, on the Chicago market, from 78 to 81 pounds. Yearlings, ewes, and old wethers of this breed are in good condition if they weigh 90 pounds in Chicago.

New Mexico sheep.—These original Mexican sheep have been largely graded with Merino rams in New Mexico and southern Colorado, and for some years were run there as grade Merinos for wool. They have not the thick wrinkly fleece of the typical Merino and show decidedly their Mexican origin, being intermediate, in length of leg, body, neck, and head, between the true Merino and the Mexican. They are a small-bodied, quick-maturing sheep, and, although never growing very large, they get very fat. It takes them longer to fatten than the better bred sheep. Never less than five and usually six months elapse from the time they are put on feed until they go to market.

The bunches of lambs brought from New Mexico run quite even in size and appearance. They are all kept under the same condition, and but few of the flocks have as yet been topped with mutton breeds so as to present any great variation from the general type. When brought to Colorado in the fall, about the 1st of November, the lambs weigh, in bunches, from 48 to 53 pounds. When shipped to Chicago, in May, they weigh from 80 to 84 pounds. Their frames are then not much larger than in the fall, but the body is much deeper, almost touching the ground, and they are almost as thick through, making them very plump. They easily get the highest prices on the Chicago market, for the same reasons as the Mexican sheep.

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[1] Bulletin 32, Colorado Experiment Station.

Merinos.—Until a few years ago, nearly all the sheep of Colorado, Wyoming, Utah, and Idaho were straight Merino sheep, bred for the most part from Merinos brought from the East. Some flocks originated from the Mexican or New Mexican sheep, but they were crossed so many times with thoroughbred Merino rams as to lose the characteristics of the southern sheep. So long as these flocks were used for wool they were carefully bred by purchasing high-priced rams from the East. As the price of wool fell, the profits decreased until some seven or eight years ago a point was reached where the sheep for mere wool ceased to be profitable. Many flocks were sold, and those sheep men that continued in the business turned their attention to wool and mutton. Many of them still continue to use Merino rams, but the number of these flocks is constantly decreasing, and, especially from western Wyoming westward, the use of rams of the mutton breeds has become almost universal. These Merino flocks from the north retain the thick fleece of the original Merino, since the climate is not hot enough to thin out the fleece as it does in New Mexico and Texas. Most of the wrinkles disappear, but a few remain around the shoulders, and the face has the Merino color distinct, being thus easily told from the southern sheep, which have no wrinkles and very thin wool around the head. The lambs are short legged and consequently not such good travelers as the southern sheep, nor do they need to be, for the Wyoming ranges will average much better than the New Mexican. The lambs appear larger than the New Mexican, but will not weigh quite so much. From 42 to 47 pounds is an average weight on the 1st of December. They grow a little more rapidly when put on feed than southern sheep, and will stand a little heavier feeding. In May they will weigh in Chicago just about the same as the southern lambs, yet, if equal bunches were put on the market together, the southern would more rapidly find a purchaser. The ewes, yearling wethers, and older wethers of the Merino are heavier than those of the southern sheep. Yearling wethers the first of December should weigh from 80 to 90 pounds; old wethers occasionally go over 100 pounds. They fatten more quickly than the lambs—much more quickly than the southern lambs. Four months' feeding is always sufficient, and many bunches will be ready for market after three months. They should weigh in Chicago from 115 to 125 pounds.

In order to compare the feeding value of this class of sheep with the native-bred mutton sheep, a carload of 252 head was obtained by the Iowa Experiment Station in the fall of 1896. They were especially selected for the experiment near Las Cruces, N. Mex., by a prominent firm of Chicago commission merchants. The shipment comprised 4 lots, designated as follows: Lot I, 63 head shorn Merino lambs; Lot II, 63 head coarse-wool New Mexicans; Lot III, 63 head Down-blood cross on Merino stock; Lot IV, 63 head of unshorn Merinos. The illustrations on the following pages furnish a good idea of the characteristics and appearances of representative lambs from each lot. They arrived at the station grounds November 3, were dipped the next day, and turned onto blue-grass pasture with a very light feed of bran and oats morning and evening; they also had access at night to good hay of which they ate freely. On December 1 they were divided as previously classified, and went into the experiment at the following weights:

Lot I, 63 head shorn Merinos, 2,950 pounds.
Lot II, 63 head coarse-wool New Mexicans, 3,330 pounds.
Lot III, 63 head Down cross, 3,390 pounds.
Lot IV, 63 head unshorn Merinos, 3,340 pounds.

During the preliminary period from November 3 to December 1 the lambs made an average gain of only about one pound per head, but the change of conditions and the dipping are, perhaps, accountable for this low result.

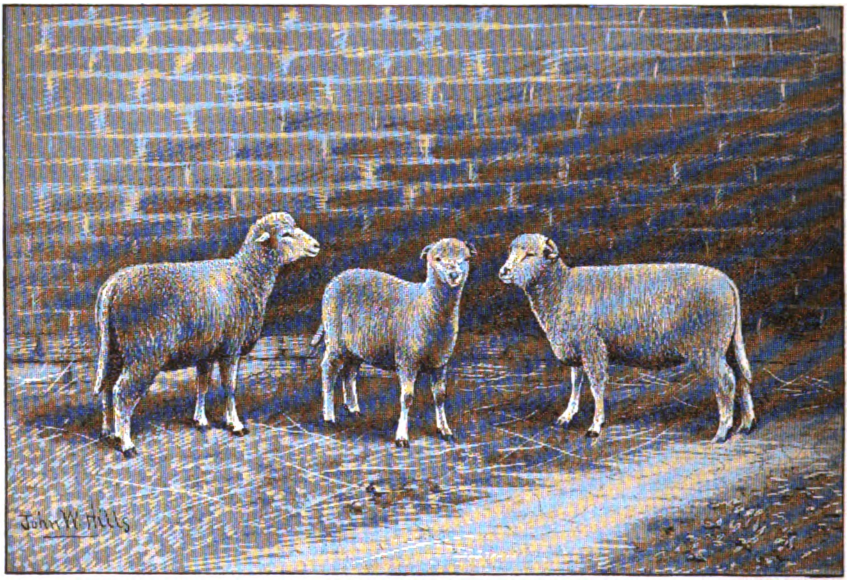

FIG. 15.—Representative lambs from Lot I, shorn Mexican Merinos.

The 252 head of lambs were fed through the entire experiment and sent to market with the following record of weights and gains for each lot during the 110 days they were on feed:

Breed.	Weight Dec. 1.	Average.	Weight Mar. 1.	Average.	Average gain.
Lot I, 63 shorn Merinos	2,950	46.9	4,796	76.1	29.2
Lot II, 63 coarse wool	3,330	52.8	5,114	81.1	28.3
Lot III, 63 Down cross	3,390	53.8	5,212	82.7	28.9
Lot IV, 63 unshorn Merinos	3,340	53	5,080	80.6	27.6
Total	13,010	51.6	20,202	80.1	28.5

The following is a complete record of the amount and cost of feed consumed during the experiment, and this table also includes other calculations that furnish a basis for comparison with pure-bred lambs, fed at the Iowa Station and elsewhere during the same and the preceding winter:

FIG. 16.—Representative lambs from Lot II, Coarse-Wool Mexicans.

Breed.	Oats.	Corn.	Bran.	Oil meal.	Mangels.	Hay.
Lot I (63) Shorn Merinos	2,785	3,135	514	324	743	14,360
Lot II (63) Coarse Wool	2,813	3,168	518	327	743	14,360
Lot III (63) Down Cross	2,813	3,168	513	327	743	14,360
Lot IV (63) Unshorn Merinos	2,728	8,069	533	317	743	14,360
Summary	11,039	12,540	2,078	1,295	2,972	57,440

Breed.	Total gains.	Average gain per head daily.	Total dry matter.	Pounds of dry matter per pound of gain.	Total cost of feed.	Cost of feed per pound of gain.
						Cents.
Lot I (63) Shorn Merinos	1,846	.266	18,253	9.88	$49.83	2.7
Lot II (63) Coarse Wool	1,784	.257	18,314	10.26	50.04	2.8
Lot III (63) Down Cross	1,822	.263	18,314	10.05	50.04	2.74
Lot IV (63) Unshorn Merinos	1,740	.251	18,153	10.43	49.50	2.84
Summary	7,192	.259	73,034	10.15	199.41	2.77

DIPPING.

Nearly all range sheep are affected with scab, though it is frequently held in check so as to be scarcely noticeable when the sheep first arrive from the range. Its development appears a few weeks later, however, and unless proper precautions are taken it becomes a serious interference with good results in fattening, besides a source of infecting the yards and premises with the germs of this disease. On this account it is generally considered best to dip all range sheep brought to the farming sections for feeding. The dipping should be done immediately or at least very soon after arrival, and repeated in about ten days to insure effective work. In case this has not been done promptly on arrival of the sheep and the disease makes its appearance during the winter, it is generally advisable to attend to the dipping without further delay, even though the weather may be quite severe, as postponement will only prolong the difficulty and at the same time cause greatly diminished gains as well as much lower value on the market. Sheep may be dipped even at a zero temperature with less menace to the flock than to allow the disease to go unchecked for a few weeks. When necessary to dip in severe weather, the work should be done under shelter in a liquid slightly warmed and the dipped animals placed immediately in dry, warm quarters and kept in for several days until the fleeces have had time to dry.

There are various dips on the market and in common use. Lime and sulphur and the tobacco dips are effective and popular where the work is done on a large scale. A number of the prepared dips on the market are equally effective, and they have the additional advantage of promoting a more favorable condition of the fleece. All farm flocks should also be dipped at least once a year for the general good effects resulting from dipping regardless of the existence of scab. (For a full discussion of dips, dipping vats, etc., see Bulletin No. 21 of the Bureau of Animal Industry, U. S. Department of Agriculture, entitled Sheep Scab.)[1]

THE FEEDING OF RANGE AND PURE-BRED LAMBS COMPARED.

The range lambs averaged only about half as much gain per head daily as the pure-bred mutton lambs. This marked difference is mainly due to the fact that the Western sheep, reared under semiarid conditions and scanty vegetation, have only about one-half as much digestive capacity as our larger breeds, accustomed to more liberal feeding. In this experiment the range lambs consumed more feed (dry matter) for a pound of gain than those of the mutton breeds. The rations were somewhat different, however, and this variation probably accounts for the larger amount of feed consumed for a given gain, as their ration consisted more largely of hay and contained a larger percentage of indigestible matter. In the first of the pure-bred lamb experiments previously described a lot of 10 northern range-bred lambs from Wyoming was fed in comparison with the mutton breeds, and it was found that, while they consumed considerably less feed than the pure-breds and gained only an average of 0.37 of a pound per head daily while the mutton breeds gained an average of 0.53, this gain was made at the rate of 1 pound for each 6.84 pounds of feed consumed, while the average for the others was 1 pound for each 7.25 pounds of feed consumed; consequently they produced this gain even a little more economically than the lambs of the improved mutton breeds. This result may seem somewhat contrary to the generally accepted doctrine concerning the value of improved blood. A principle of feeding which has been quite clearly established is that animals of pure breeding, whether sheep, cattle, or hogs, are not capable of rendering much, if any, higher returns for a given amount of feed than the so-called "scrub," or native unimproved stock. This matter seems to be governed by the powers of digestion which are not materially modified by artificial conditions. The chief value of improved blood lies in the capability of higher excellence of finished product and a correspondingly higher selling value. Similar results have also been obtained at other experiment stations where feeding tests have been carefully conducted. In an experiment

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[1] Bulletin No. 38, Colorado Experiment Station, also contains much valuable information on the same subject.

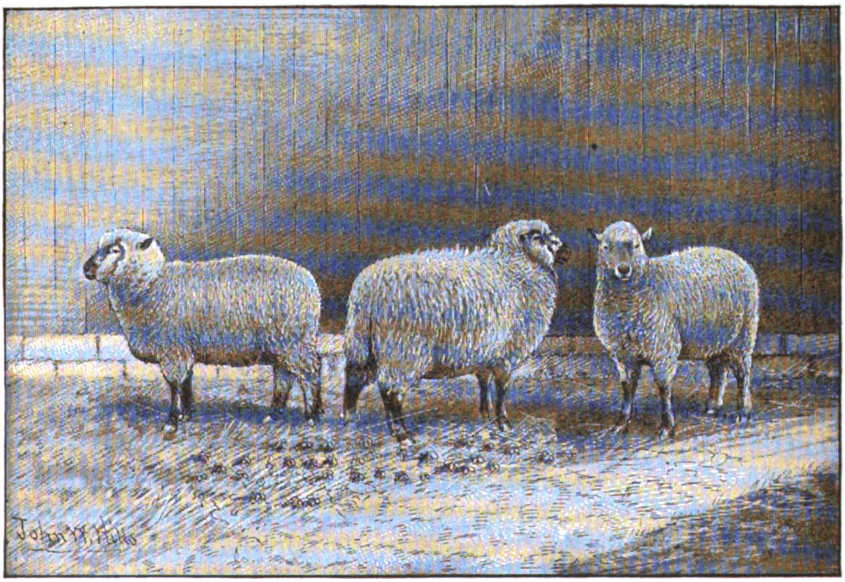

FIG. 17.—Representative lambs from Lot III, Down cross on Merino foundation.

conducted at the Minnesota Experiment Station by Prof. Thomas Shaw, similar conclusions were reached.

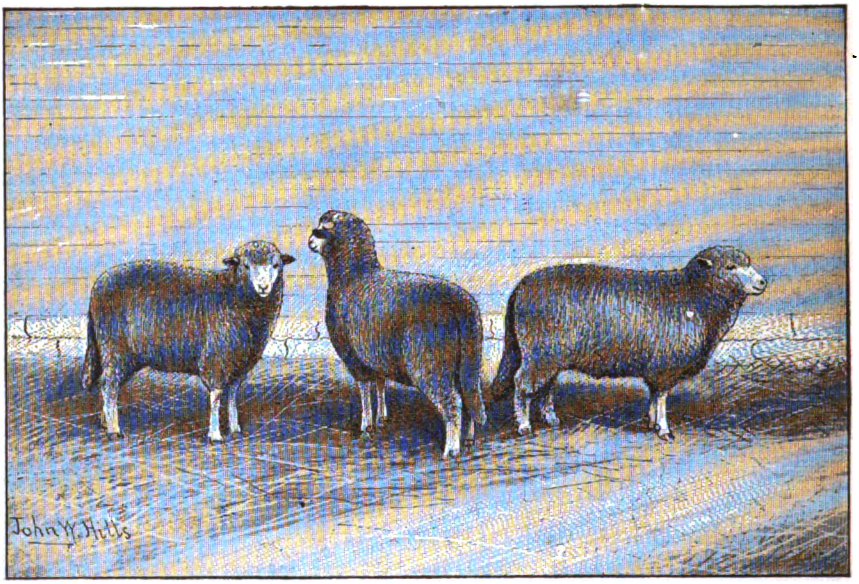

FIG 18.—Representative lambs from Lot IV, unshorn Mexican Merinos.

THE VALUE OF IMPROVED BLOOD.

It has sometimes been asserted that some of the native unimproved lambs are superior for feeding purposes and mutton production to the improved mutton breeds. This conclusion probably had its origin in the fact that the Mexican and other types of range-bred lambs have at times been quoted as high, and in some instances a little higher, than any other lambs on the market. This is due to other reasons, however, and does not justify the conclusion that no advantage results from improved breeding. The relatively high price at which range lambs sometimes sell is largely due to the fact that they are of the desired light weight, and, owing to the long distance in shipping, they are well shrunken when they reach the market and kill out a better percentage of net meat than would otherwise be the case. Notwithstanding these points in their favor, however, the best mutton lambs marketed by the Iowa Experiment Station have always outsold the best range lambs on the market by from 15 to 25 cents per hundredweight. The home-bred lambs made a larger net profit per lamb in the comparison at the Minnesota Station, even though they were rather an inferior lot, but they did not gain as rapidly or as economically as the range lambs.

In the range-lamb feeding experiment conducted at the Iowa Station, one lot had a cross of improved blood (evidently from one of the Down breeds) and the others had not. These lambs, raised under the same conditions on the range, and finished under the same conditions in the feed yard, sold for a higher price and returned a higher net profit than the other lots, though they made no larger gains. The profit made on the several lots is shown below:

Breed.	Selling price.	Net profit per head.
Lot I, Shorn Merinos	$4.75	$0.42
Lot II, Coarse Wool	5.15	.75
Lot III, Down Cross	5.25	.87
Lot IV, Unshorn Merinos	5.00	.70

At the Wisconsin Experiment Station[1] Prof. John A. Craig obtained a profit of $1.13 per head from well-bred lambs, against 65 cents from unimproved northern Wisconsin lambs fed under similar conditions.

WHAT CONSTITUTES A GOOD SHEEP.

The value of good blood has been emphasized in preceding pages. Not all the animals belonging to any of the improved breeds, however, are possessed of a high degree of excellence. No graver error can be made than the assumption of uniform excellence in the stock constituting any breed, no matter how much prominence it may have attained. Individual animals always differ more than breeds; and there are relatively few really good animals in any breed. This seems to be strikingly true of the mutton sheep. The chief trouble in mutton production is and always has been the scarcity of stock sheep, particularly sires, that have sufficient merit to fill the standard of excellence for a strictly prime carcass. Until we reach this higher degree of excellence the mutton sheep will not assume its rightful place in American agriculture. The American market has become the most discriminating in the world on beef products, and it will demand a corresponding superiority in mutton. With this in view a brief consideration of what constitutes a good mutton sheep may be of interest.

First, let there be pronounced masculinity in the male and femininity in the female. Sheep should be neither sexless nor characterless. They should bear the stamp and character of the breed they represent. This breed character is a mark of good blood, and it should be manifest in no unmistakable manner. The sire should be impressive, resolute, and of noble bearing. He should be distinctly the head of the flock in every sense of the word. To meet these requirements he must have good constitutional and vital powers. Without these no animal is fit to head a herd or flock. In selecting a sire, look first at the head. If deficient there, look no further, but reject at once. Insist upon a head that faces you boldly with a wide face, a clear, prominent eye, and a robust character throughout. The head should be joined to a well-filled, round, muscular neck, wide at the poll and back of the ears and gradually enlarging in all lines to a strong, full junction at the shoulder, as seen from top, sides, or bottom. This should be accompanied by a wide chest, a prominent, well-filled brisket, and a full heart girth, giving straight, even lines from the shoulders back. A depression either in front of or behind the shoulder, whether at the top, side, or bottom line is an indication of weakness. The back should be strong, wide, and well meated from shoulder point to tail. The hind quarters should be full and well let down in the leg and flank, in order to yield well of high-priced meat. The legs should be placed wide apart and stand straight. Sickle-shaped hocks and weak, sloping pasterns afford sufficient reason for condemning an otherwise good sheep.

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[1] Annual Report Wisconsin Experiment Station, 1896.

ESSENTIALS OF A GOOD FLEECE.

The modern mutton sheep must also be a wool producer. Our future wool supply must come largely from sheep grown primarily for mutton. It is essential, then, that a mutton sheep have a good fleece as well as a good carcass. This combination is both practicable and profitable; and it is no longer regarded necessary to grow one sheep for a fleece, another for a carcass, and another for a lamb. The intelligent flockmaster combines them all in one class. Some of the best mutton sheep are producing as profitable fleeces as those kept exclusively for wool, and their lambs are decidedly superior. One of the first essentials in a good fleece is compactness or density. This quality not only insures a better yield of wool, but it affords better protection against storm and indicates a hardier animal, better able to withstand exposure. A close, even, dense fleece with no breaks should cover all parts of the body, including the head, limbs, and under parts. The tendency in improvement of the wool-producing qualities of all modern breeds has been toward carrying the fleece more completely over the head, face, limbs, and lower line. The advantage is not so much in the increased yield of wool grown on these parts, as that is of little consequence, but in the accompanying tendency to a larger and better yield of wool in all parts. A barefaced and barelegged sheep is always a relatively light shearer, and in contrast with this the sheep wooled from "the eyes to the toes" always yields a heavy fleece and the wool is generally of a better quality than from those having a scanty covering.

Fineness, length, and strength of fiber are essential qualities in a good fleece that should always have prominent consideration in the selection of breeding stock, as these qualities largely determine the market value. Neglect or undue exposure of the flock, a period of sickness, or anything that induces unthrift and impaired vitality invariably results in diminishing both the length and strength of fiber. Well-fed sheep always produce the most and best wool. Softness and pliancy of wool usually correspond in degree with fineness. Harshness and dryness are always detrimental to the quality, even if the fiber is otherwise good. As a rule, this condition may be taken as an indication of poor breeding, although it may be due to disease, old age, or improper treatment. Generally, a fleece begins to decline in value and yield after a sheep becomes 4 years old. Softness and pliancy are to a considerable extent due to the secretions of the skin. A clear pink or yellowish skin is an indication of a good quality of wool, while a pale or bluish skin is generally accompanied by an inferior fleece. The yolk is the oily secretion which gives color, softness, pliancy, and luster to the fleece. The composition of the yolk consists of a soapy matter, principally animal oil and potash, which promotes the growth of the fleece and prevents friction, wearing of the fibers, and cotting. Good feeding, shelter, and care promote liberal secretion of yolk, while exposure and alkali soils result in injury to wool by diminishing the yolk. The secretions are always more abundant under high temperature, hence blanketing and confinement in close, warm quarters will stimulate the production and insure a finer fiber. A liberal secretion of yolk is favorable to the production of a good fleece, but the yolk should be clear and transparent and not too thick and gummy. In addition to these qualities, a fleece should possess the properties of evenness and uniformity; this refers to covering, density, and quality. A good fleece should be as nearly uniform in all parts as practicable. Avoid the fleeces that run to coarse, kempy fibers at the thighs and along the lower line. The best grade and quality of wool is found on the rear part of the shoulder, and the nearer all other parts of the fleece measure up to this standard in length and fineness of fiber the higher will be its value. Wrinkles or folds of the skin about the neck or other parts of the body are detrimental, as the wool that grows within these folds is unlike the others parts of the fleece, and there is a consequent lack of uniformity.

GENERAL NOTES ON SHEEP FEEDING.

The range lambs that are driven or shipped eastward to be finished on grain feeds are largely divided into two general classes—the northern coming mainly from Wyoming and Montana, and the southern from New Mexico and Arizona. Besides this there are a good many that are annually grazed in Colorado, Idaho, Utah, and other States. Large numbers, mainly from southern ranges, are fed annually in the vicinity of Fort Collins and Rocky Ford, Colo.; and at New Brighton and South St. Paul, Minn., northern range lambs are fed extensively each winter, being fattened principally upon screenings from the large mills in the vicinity of St. Paul and Minneapolis. About 200,000 head of sheep and lambs have been fed there during the past winter (1898–99). The feeders in the vicinity of Fort Collins handle about an equal number, and Rocky Ford somewhat less, although this point is rapidly increasing in capacity for furnishing good mutton lambs in large numbers. During the winter of 1897–98 the feeders of Nebraska handled nearly 1,000,000 head; this winter (1898–99) the number is estimated at a little more than half that amount. Iowa, Illinois, and other States annually finish for market large numbers of western sheep. A total of about 2,000,000 head in all is now annually finished for market in the feed lots of the Middle and Western States.[1] The abnormally high price of range sheep and lambs for feeding purposes prevailing last summer and at the beginning of the feeding season largely reduced the number put on feed in some localities, and the past winter's experience has been somewhat disastrous to a good many feeders, particularly at New Brighton and St. Paul. This result may be attributed to two causes—namely, extreme prices paid for feeding stock and an advance of nearly 100 per cent in the price of screenings. The loss incurred, however, need not militate against the mutton-producing industry; it only serves as another illustration that unwarranted or boom prices are never safe in live-stock production of any kind. Sheep raising conducted carefully and conservatively has paid those who have been engaged in it notwithstanding the decline in prices during the past six months; it has paid the range men extremely well, and it has paid the farmer who breeds and matures his own flock; also the farmer who has bought feeders at a reasonable figure to consume his surplus farm grains. At New Brigton sheep are fattened almost exclusively on screenings that generally retail at about $4 per ton. A light grade of screenings containing less grain and more bulky coarse material is considered best at the beginning, when sheep are being put on feed, and a heavier and richer grade is used for finishing.

THE SELF-FEEDER.

The self-feeder is extensively employed where screenings are used. At other points, however, where corn constitutes the chief grain ration, the self-feeder is not in favor, and its use is not to be recommended for sheep feeding under farm conditions, though it is recommended by some successful cattle feeders. The economy of the self-feeder constituted the subject of an experiment by Prof. F. B. Mumford, of Michigan,[2] with the following results:

Results of a feeding experiment.

Method of feeding.	Lots.	Grain.	Hay.	Water.	Cost of feed.	Total gain per lamb.	Average weekly gain.	Dry matter to 1 pound gain.
		Lbs.	*Lbs.*	*Lbs.*		*Lbs.*	*Lbs.*	*Lbs.*
Ordinary	2	1,164	1,173	2,073	$14.24	23.0	1.77	8.77
Self-feed	7	1,460	924	2,547	15.47	20.6	1.58	10.04

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[1] Peter Jansen. Proceedings of the National Stockmen's Convention, January, 1899.

[2] Bulletins 127, 128, Michigan Experiment Station.

The conclusions drawn concerning the use of the self-feeder at the Michigan Experiment Station are stated as follows: "Feeding by means of a self-feeder is an expensive method of fattening, and is not to be recommended either from the standpoint of total gains made or the amount of dry matter required to produce a given gain."

In Nebraska and other States, where large numbers are fed, a liberal supply of hay of good quality and at a moderate price constitutes an important factor. For this purpose perhaps nothing is superior or quite equal to properly cured alfalfa. Many large feeders have been buying extensive areas of alfalfa in Nebraska during recent years, and at other points accessible for corn feeding. Millet hay and straw are also used to a considerable extent in fattening sheep, but they are less desirable. A dry, keen, winter atmosphere is favorable to sheep feeding and conducive to general thrift of the flock and large gains; on the other hand, damp, murky weather always means unsatisfactory results.

Many of the largest feeders in Nebraska, Colorado, Minnesota, and elsewhere have no shelter, but considerable difficulty and loss are experienced in severe winters. It is generally conceded that properly constructed sheds are an advantage, though they are somewhat expensive for large feeding yards. Where the sheep are handled in smaller numbers, however, shelter is generally provided and considered profitable. A constant and liberal supply of bedding is of even greater importance than shelter, and water and salt should be accessible to fattening sheep at all times. The water supply constitutes an important factor, and any irregularity concerning it always entails loss.

REGULAR FEEDING ESSENTIAL.

Regularity and uniformity in feeding are of prime importance. Some of the most successful feeders manage a large feeding establishment with absolute regularity and precision. The system generally practiced consists in having a feeding yard separate from the other quarters. One feeding yard serves for five to ten lots of sheep ranging from three to five hundred in number. The grain ration is placed in the troughs and the sheep admitted and returned to their regular quarters in ten or fifteen minutes after the grain is eaten. The sheep themselves become wonderfully punctual and regular in their habits. When properly managed, the feeding begins at precisely the same time and proceeds in regular order each day. This procedure becomes so well understood by the sheep that they always expect their ration promptly on time, and they will take their place at the gate admitting them to the feed yard in regular order by lots. For instance, lot one at its feeding time will be waiting for admittance while lot two in the pen adjoining five minutes before feeding time will be lying contentedly and taking no notice of what is going on outside; a few minutes later, however, they will be crowded at the gate and eagerly waiting their turn. When the feeder is a quarter of an hour late, every animal in the lot seems to recognize and resent his tardiness.

Attention to these and numerous other minor details have a great deal to do with the profits resulting from extensive feeding operations. The loss from indigestion and other troubles frequently reaches 4 or 5 per cent under negligent methods, but in careful, judicious handling this can be reduced to less than 1 per cent.

Restricting the amount of grain to a very limited quantity at the beginning is absolutely essential to the best results in fattening western sheep; a lighter grain feed should then be used in preference to one that is more concentrated, and during the finishing stages a heavier and richer grain ration will be productive of good results.

FEEDING THREE TIMES A DAY.

On one of the largest and most successful feeding ranches in the West, near Jansen, Nebr., 2,500 head, in lots of about 300 each, were being fattened on a grain ration consisting of 1½ pounds of shelled corn and one-eighth of a pound of oil meal per head daily at the time of the writer's visit there in February. They were being fed grain three times daily in separate feeding yards adjoining their other quarters, according to the system previously described in this bulletin. The manager of the sheep at this farm recommends feeding three times a day, although it is not common to feed more than twice. Those who have practiced feeding three times a day claim as an advantage for this method that larger quantities of grain may be consumed with less danger of injury than by feeding only twice. One feeder who has recently introduced this method stated that he was able to safely feed 300 pounds more grain per day to 2,500 head of sheep. A striking illustration in favor of careful methods is furnished in the following record: Three lots, ranging from 500 to 1,500 each, all selected from the same large bunch shipped in from the range together, went into the hands of different feeders. One, the largest lot, made an average gain of 20 pounds in five months, another, 13, and the third, 9. They went to market at about the same time and sold for $4.55, $4.40, and $4.35, respectively. The difference in gain and value of the sheep on the market when finished was enough to return a liberal profit on the best lot, while it was with difficulty that the others were able to balance accounts. These differences prevail in other localities and demonstrate the advantage and increased profit that always result where right methods are applied. Careful feeders by giving strict attention to all essentials are able to make average gains of 8 or 10 pounds per head monthly on range lambs and 10 to 15 pounds on well-bred mutton lambs.

REQUISITES OF A GOOD SHEPHERD.

A flock of sheep can not be handled or fattened successfully without a close observance of their habits and peculiarities. There are a great many little things that enter into the attention and management by a successful shepherd that may seem trivial, yet they have much to do with the comfort, thrift, and profit of the flock. The axiom that "The eye of the master fattens" is nowhere more applicable than in the sheepfold. The competent feeder acquires a trained eye, that detects at a glance any evidence of disorder that will be manifest if a single animal is off of feed or out of condition. To the unobserving or inexperienced feeder sheep all look alike, but when rightly studied no class of stock presents more marked individual peculiarities or so clearly manifests evidence of thrift and well-doing or the reverse. Attention to these little details, accompanied by regular habits and a quiet manner, constitutes the keynote of successful sheep feeding. Nothing contributes more to good results than contentment and quiet surroundings. The feeder who disturbs the quiet and comfort of the flock every time he goes about it should quit the sheep business at once. Rough manners and harsh treatment absolutely disqualify any man for success in this work. The natural timidity and nervous temperament of the sheep necessitate gentle treatment. Their dainty habits about eating and drinking must also be indulged as fully as practicable. No animal naturally selects a wider variety of feed, particularly of rough forage and vegetation; but two essentials are always exacted, viz, cleanliness and palatability. Never give a sheep any stale or undesirable feed, nor expect it to eat any feed left over from a previous meal. The ration should be always wholesome and tempting to the appetite. The barn or stabling quarters should never be without a fresh, pure atmosphere and an ample supply of dry bedding. Sheep rarely suffer from cold if kept dry and protected from direct drafts. The open air is better than a poorly kept shed or barn.

WHEN IS A LAMB FAT?

It is important that the practical feeder be able to determine when lambs are properly finished and in the most satisfactory and profitable condition for the market. This is not always an easy task; experienced feeders are sometimes deceived. As an aid in studying this matter, the following directions, prepared by Prof. John A. Craig, of the animal husbandry department of the Iowa Agricultural College, for the instruction of students, are of interest:

> When put into the feed lot under proper conditions, lambs will usually begin to show the influence of good feeding at the end of the third or fourth week. During this time they seem to be simply getting into good condition to put on flesh, though it appears that some flesh is being deposited internally. Toward the end of that time many of the lambs may be noticed standing leisurely in the sun in a partially stretched posture. This pose in the lambs is a delight to the shepherd. The fattening process seems to extend from the internal regions, and is first in evidence at the tail. It then passes along the back over the shoulder and reaches the neck; from this line it seems to extend down the sides and over the breast in front. There are six main points at which its extension seems most in evidence—at the tail, middle of the back, the neck, the flank, the purse, and the breast. Judges of condition

handle these different points, and seem to arrive at the same conclusions from continued practice in observing the development in any one of them, although a critical examination will reveal that lambs sometimes fatten unevenly and may be good in one or more of these points and comparatively deficient in others. By feeling the tail head some will form their opinions as to the degree to which the lamb is fat. Others are satisfied with feeling the back. Many after feeling the tail grasp the neck and base their opinion on the fullness of that part. The flank and breast are often used for further assistance, and some butchers estimate condition from the fullness of the purse. At any of these points, more especially the back, the covering should be such in the prime lamb as to prevent feeling the sharp projections of the backbone. In fact, it can hardly be said that a lamb is really prime unless instead of a projection of backbone there is a distinct trough or groove running from the tail to the shoulders, and this covering should extend well down over the sides without softness due to excessive fat or oily tissue. All lambs do not fatten as smoothly or as uniformly as herein indicated. In most lambs, however, the worst defect is bareness of the loin and lightness in the hind quarters. With these parts well covered and fully developed, a rather sharp shoulder and peaked brisket may be overlooked. Not only should the flesh be thick over the valuable cuts, but it should be firm. Very often it will be found that soft rough patches will be present about the head of the tail, owing to the depositing of too much soft flesh on the back, which may slip from there on the overripe lamb and gather at the flank or along the sides in long soft rolls.

FARMERS' BULLETINS.

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No. 16. Leguminous Plants for Green Manuring and for Feeding. No. 19. Important Insecticides: Directions for their Preparation and Use. No. 21. Barnyard Manure. No. 22. Feeding Farm Animals. No. 23. Foods: Nutritive Value and Cost. No. 24. Hog Cholera and Swine Plague. No. 25. Peanuts: Culture and Uses. No. 26. Sweet Potatoes: Culture and Uses. No. 27. Flax for Seed and Fiber. No. 28. Weeds; and How to Kill Them. No. 29. Souring of Milk and Other Changes in Milk Products. No. 30. Grape Diseases on the Pacific Coast. No. 31. Alfalfa, or Lucern. No. 32. Silos and Silage. No. 33. Peach Growing for Market. No. 34. Meats: Composition and Cooking. No. 35. Potato Culture. No. 36. Cotton Seed and Its Products. No. 37. Kafir Corn: Characteristics, Culture, and Uses. No. 38. Spraying for Fruit Diseases. No. 39. Onion Culture. No. 40. Farm Drainage. No. 41. Fowls: Care and Feeding. No. 42. Facts About Milk. No. 43. Sewage Disposal on the Farm and Protection for Drinking Water. No. 44. Commercial Fertilizers: Composition and Use. No. 45. Some Insects Injurious to Stored Grain. No. 46. Irrigation in Humid Climates. No. 47. Insects Affecting the Cotton Plant. No. 48. The Manuring of Cotton. No. 49. Sheep Feeding. No. 50. Sorghum as a Forage Crop. No. 51. Standard Varieties of Chickens. No. 52. The Sugar Beet. No. 53. How to Grow Mushrooms. No. 54. Some Common Birds in Their Relation to Agriculture. No. 55. The Dairy Herd: Its Formation and Management. No. 56. Experiment Station Work—I. No. 57. Butter Making on the Farm. No. 58. The Soy Bean as a Forage Crop. No. 59. Bee Keeping. No. 60. Methods of Curing Tobacco. No. 61. Asparagus Culture. No. 62. Marketing Farm Produce. No. 63. Care of Milk on the Farm. No. 64. Ducks and Geese: Standard Breeds and Management. No. 65. Experiment Station Work—II. No. 66. Meadows and Pastures in the Middle Eastern States. No. 67. Forestry for Farmers. No. 68. The Black Rot of the Cabbage. No. 69. Experiment Station Work—III. No. 70. The Principal Insect Enemies of the Grape. No. 71. Some Essentials in Beef Production. No. 72. Cattle Ranges of the Southwest. No. 73. Experiment Station Work—IV. No. 74. Milk as Food. No. 75. The Grain Smuts; How They are Caused and How to Prevent Them. No. 76. Tomato Growing. No. 77. The Liming of Soils. No. 78. Experiment Station Work—V. No. 79. Experiment Station Work—VI. No. 80. The Peach Twig-borer: An Important Enemy of Stone Fruits. No. 81. Corn Culture in the South. No. 82. The Culture of Tobacco. No. 83. Tobacco Soils. No. 84. Experiment Station Work—VII. No. 85. Fish as Food. No. 86. Thirty Poisonous Plants. No. 87. Experiment Station Work—VIII. No. 88. Alkali Lands. No. 89. Cowpeas. No. 90. The Manufacture of Sorghum Sirup. No. 91. Potato Diseases and Their Treatment. No. 92. Experiment Station Work—IX. No. 93. Sugar as Food. No. 94. The Vegetable Garden. No. 95. Good Roads for Farmers. No. 96. Raising Sheep for Mutton. No. 97. Experiment Station Work—X. No. 98. Suggestions to Southern Farmers. No. 99. Three Insect Enemies of Shade Trees. No. 100. Hog Raising in the South. No. 101. Millets. No. 102. Southern Forage Plants. No. 103. Experiment Station Work—XI. No. 104. Notes on Frost. No. 105. Experiment Station Work—XII. No. 106. Breeds of Dairy Cattle. No. 107. Experiment Station Work—XIII. No. 108. Saltbushes. No. 109. Farmers' Reading Courses. No. 110. Rice Culture in the United States. No. 111. The Farmer's Interest in Good Seeds. No. 112. Bread and the Principles of Bread Making. No. 113. The Apple and How to Grow It. No. 114. Experiment Station Work—XIV. No. 115. Hop Culture in California. No. 116. Irrigation in Fruit Growing. No. 117. Sheep, Hogs and Horses in the Pacific Northwest. No. 118. Grape Growing in the South. No. 119. Experiment Station Work—XV. No. 120. The Principal Insects Affecting the Tobacco Plant. No. 121. Beans, Peas, and Other Legumes as Food. No. 122. Experiment Station Work—XVI. No. 123. Red Clover Seed: Information for Purchasers. No. 124. Experiment Station Work—XVII. No. 125. Protection of Food Products from Injurious Temperatures. No. 126. Practical Suggestions for Farm Buildings. No. 127. Important Insecticides. No. 128. Eggs and Their Uses as Food. No. 129. Sweet Potatoes. No. 130. The Mexican Cotton Boll Weevil. No. 131. Household Test for Detection of Oleomargarine and Renovated Butter. No. 132. The Principal Insect Enemies of Growing Wheat. No. 133. Experiment Station Work—XVIII.

U. S. DEPARTMENT OF AGRICULTURE.

FARMERS' BULLETIN No. 97.

Experiment Station Work,

X.

MANURE FROM COWS.
PLANTS FOR ALKALI SOILS.
INFLUENCE OF ALKALI ON PLANTS.
FEEDING VALUE OF THE CORN PLANT.
SOWS AND PIGS AT FARROWING TIME.
THE SOY BEAN AS A FEEDING STUFF.
ALFALFA HAY FOR HOGS.
ANIMAL MATTER FOR POULTRY.
WATER AND ANIMAL DISEASES.
CONSTRUCTION AND COOLING OF CHEESE-CURING ROOMS.
IRRIGATION INVESTIGATIONS.

PREPARED IN THE OFFICE OF EXPERIMENT STATIONS.

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1899.

CONTENTS OF THE SERIES OF FARMERS' BULLETINS ON EXPERIMENT STATION WORK.

I. (Farmers' Bul. 56).—Good v. Poor Cows; Corn v. Wheat; Much v. Little Protein; Forage Crops for Pigs; Robertson Silage Mixture; Alfalfa; Proportion of Grain to Straw; Phosphates as Fertilizers; Harmful Effects of Muriate of Potash; Studies in Irrigation; Potato Scab; Barnyard Manure.

II. (Farmers' Bul. 65).—Common Crops for Forage; Stock Melons; Starch in Potatoes; Crimson Clover; Geese for Profit; Cross Pollination; A Germ Fertilizer; Lime as a Fertilizer; Are Ashes Economical? Mixing Fertilizers.

III. (Farmers' Bul. 69).—Flax Culture; Crimson Clover; Forcing Lettuce; Heating Greenhouses; Corn Smut; Millet Disease of Horses; Tuberculosis; Pasteurized Cream; Kitchen and Table Wastes; Use of Fertilizers.

IV. (Farmers' Bul. 73).—Pure Water; Loss of Soil Fertility; Availability of Fertilizers; Seed Selection; Jerusalem Artichokes; Kafir Corn; Thinning Fruit; Use of Low-grade Apples; Cooking Vegetables; Condimental Feeding Stuffs; Steer and Heifer Beef; Swells in Canned Vegetables.

V. (Farmers' Bul. 78).—Humus in Soils; Swamp, Marsh, or Muck Soils; Rape; Velvet Bean; Sunflowers; Winter Protection of Peach Trees; Subwatering in Greenhouses; Bacterial Diseases of Plants; Grape Juice and Sweet Cider.

VI. (Farmers' Bul. 79).—Fraud in Fertilizers; Sugar-beet Industry; Seeding Grass Land; Grafting Apple Trees; Forest Fires; American Clover Seed; Mushrooms as Food; Pigs in Stubble Fields; Ensiling Potatoes; Anthrax.

VII. (Farmers' Bul. 84).—Home-mixed Fertilizers; Forcing Asparagus in the Field; Field Selection of Seed; Potatoes as Food for Man; Corn Stover as a Feeding Stuff; Feeding Value of Sugar Beets; Salt-marsh Hay; Forage Crops for Pigs; Ground Grain for Chicks; Skim Milk for Young Chickens; By-products of the Dairy; Stripper Butter; Curd Test in Cheese Making; Gape Disease of Chickens.

VIII. (Farmers' Bul. 87).—Soil Moisture; Fertility of Soils; Cover Crops for Orchards; Cultivating v. Cropping Orchards; Transplanting Trees; Fecundity of Swine; Food Value of Eggs; Starch from Sweet Potatoes; The Toad as a Friend of the Farmer.

IX. (Farmers' Bul. 92).—Sugar Beets on Alkali Soils; Planting and Replanting Corn; Improvement of Sorghum; Improved Culture of Potatoes; Second-crop Potatoes for Seed; Cold v. Warm Water for Plants; Forcing Head Lettuce; The Date Palm in the United States; The Codling Moth; Jerusalem Artichokes for Pigs; Feeding Calves; Pasteurization in Butter Making; Gassy and Tainted Curds; Pure Cultures in Cheese Making.

LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
OFFICE OF EXPERIMENT STATIONS,
Washington, D. C., May 5, 1899.

SIR: The tenth number of Experiment Station Work, prepared under my direction, is transmitted herewith with the recommendation that it be published as a Farmers' Bulletin.

Respectfully,

A. C. TRUE,
Director.

Hon. JAMES WILSON,
Secretary of Agriculture.

CONTENTS.

Page.
The value of the manure from cows 5
Plants adapted to alkali soils 6
Influence of alkali on the germination and growth of plants 8
The feeding value of the corn plant at different stages of growth 9
Sows and pigs at farrowing time 12
The soy bean as a feeding stuff 13
Alfalfa hay for hogs 15
Animal matter a necessity for poultry 16
Relation of water supply to animal diseases 17
Cooling of cheese-curing rooms 19
  Cooling by ventilating with night air 19
  Cooling by ventilating through horizontal subearth ducts 20
  Cooling by ventilating through deep vertical subearth ducts 21
  Cooling the soil for short ducts 22
  Cooling with air forced through cold water 23
Construction of cheese-curing rooms 23
  Wooden above-ground curing room 25
  Underground curing rooms 25
  Central cheese-curing rooms 26
Irrigation investigations 27
Explanation of terms 30
  Terms used in discussing fertilizers 30
  Terms used in discussing foods and feeding stuffs 30
  Miscellaneous terms 31

ILLUSTRATIONS.

Page.
FIG. 1. Section of cheese-curing room and horizontal multiple subearth duct .. 20
2. Showing how funnel and vane may be mounted 21
3. Showing vertical subearth duct 22
4. Showing method of cooling air with cold water 24
5. Showing the construction of wooden curing room 26

EXPERIMENT STATION WORK—X.[1]

THE VALUE OF THE MANURE FROM COWS.

In experiments with dairy cows at the Texas Station a record was kept of the fertilizing constituents in the feeding stuffs used and in the excrement voided. The experiment was made with 18 Jersey or Holstein grade cows and extended over fifty-six days. The feeding stuffs used included corn meal, bran, oats, cotton-seed meal, cotton-seed hulls, silage, and sorghum hay. The calculated fertilizing value of the 651.6 pounds of corn meal consumed during the fifty-six days was $1.53; of the 745.6 pounds of bran, $3.85; 632.2 pounds of oats, $1.97; 5,464.2 pounds of cotton-seed meal, $54.25; 14,300.6 pounds of cotton-seed hulls, $21.59; 20,009.3 pounds of silage, $11.21; and 2,848.6 pounds of sorghum hay, $5.70, making the total value of the fertilizing constituents in the food consumed during the experiment $100.10. The total cost of the feeding stuffs used during the same time was $123.24. If all of the fertilizing constituents of the food could have been returned to the soil in the manure, the net cash outlay for the production of milk and butter in the above experiments would have been only $23.14.

Of course all the fertilizing material of the food does not pass through the alimentary canal into the excrements; some is retained to aid in the formation of flesh, bone, and milk. In the case of average milk cows this is estimated at 20 per cent. Allowing for this loss, the fertilizing value of the foods used in this experiment is still $80.08, making the net food cost $43.16. If the excrements from the cows are carefully preserved, by far the largest percentage of the fertilizing constituents can be successfully returned to the soil. Supposing, however, that only 50 per cent is returned to the farm, we still have a fertilizing value in these foods of $50.05, and then the net cash outlay for the foods consumed would only rise to $73.19. Thus, in determining the cost of milk and butter production, the fertilizing value of the food stuffs must be carefully considered. By many it is held that the fertilizing material secured to the farm through stock husbandry covers the cost of care and feeding, whether beef or milk forms the object.

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[1] This is the tenth number of a subseries of brief popular bulletins compiled from the published reports of the agricultural experiment stations and kindred institutions in this and other countries. The chief object of these publications is to disseminate throughout the country information regarding experiments at the different experiment stations, and thus to acquaint our farmers in a general way with the progress of agricultural investigation on its practical side. The results herein reported should for the most part be regarded as tentative and suggestive rather than conclusive. Further experiments may modify them, and experience alone can show how far they will be useful in actual practice. The work of the stations must not be depended upon to produce "rules for farming." How to apply the results of experiments to his own conditions will ever remain the problem of the individual farmer.—A. C. TRUE, Director, Office of Experiment Stations.

With the above data before us, this proposition seems fair and reasonable, and certainly points out the fact that this feature, so long neglected in our domestic economy, should receive careful attention. * * *

In farming, where the purchase of food may be necessary, the above facts should be carefully considered; for, if foods have to be bought, the farmer should secure the food best adapted to his purpose in feeding and furnishing the highest percentage of valuable fertilizing materials at the same time. By this means the fertility of the farm may be properly conserved and enlarged.

The following table, taken from a Farmers' Bulletin of this Department (No. 44), shows the variations in the fertilizing constituents in some of the more common farm products, and indicates the directions in which selections of feeding stuffs may be made:

Manurial constituents contained in one ton of various farm products.

	Nitrogen.	Phosphoric acid.	Potash.
	Pounds.	*Pounds.*	*Pounds.*
Meadow hay	20.42	8.2	26.4
Clover hay	40.16	11.2	36.6
Potatoes	7.01	3.2	11.4
Wheat bran	49.15	54.6	28.6
Linseed meal	105.12	32.2	24.8
Cotton-seed meal	135.65	56.2	29.2
Wheat	37.58	15.8	10.6
Oats	36.42	12.4	8.8
Corn	33.08	11.8	7.4
Barley	39.65	15.4	9.0
Milk	10.20	3.4	3.0

PLANTS ADAPTED TO ALKALI SOILS.

Throughout the western portion of the United States, especially where irrigation is practiced, areas of alkali soils of greater or less extent are of frequent occurrence. These soils derive their name from the fact that they are strongly impregnated with soluble salts, which effloresce or "bloom out" in the form of a powder or crust during dry weather following rains or irrigation. The basis of these salts is mainly soda, together with smaller amounts of potash and usually a little lime and magnesia. They are mixtures chiefly of sodium sulphate, sodium chlorid (common salt), and sodium carbonate in varying proportions. They often contain in addition small amounts of potassium sulphate, sodium phosphate, and sodium nitrate, substances whose fertilizing value is well known.

The California Station has found the amount of soluble salts in the alkali soils of that State to vary from less than 1 to over 12 per cent. Stated in another way, this means that the amount present may be as high as 500,000 pounds per acre. Usually, however, it ranges from 5,000 to 40,000 pounds per acre. Of the different forms of alkali, that in which sodium carbonate predominates (black alkali) "is by far the most injurious to vegetable growth and to the tilling qualities of the soil; common salt (sodium chlorid) ranks next in injuriousness; while sodium sulphate is the least injurious and may be present to the extent of half of 1 per cent or more without materially interfering with the growth of most crops. It follows that in the reclamation of alkali lands for cultural purposes the first thing needful is a transformation of the sodium carbonate, if present, into sodium sulphate by means of gypsum (land plaster), reducing the injuriousness of the black alkali one-fourth to one-fifth." Experiments by the California Station have shown that in order to accomplish this successfully it is necessary to add to the soil from two and one-half to three times as much gypsum as there is sodium carbonate present.

While the occurrence of alkali in excess in the soil constitutes a serious menace to the successful production of most farm crops, recent investigations have shown that there are many plants of economic value which are able to tolerate a considerable amount of alkali. The experiment stations of California and other Western States have devoted considerable attention to the subject of the utilization of alkali soils, studying especially the relation of native and cultivated plants to alkali. The investigations of the California Station have shown that the resistance to alkali varies greatly with the kind of plant and the character of the salts in the alkali.

Thus, the plants of the goosefoot family, comprehending, besides the goosefoot proper, the beet, spinach, samphire, saltwort, and the saltbushes generally, will resist very large amounts of all three of the salts; while, on the other extreme, the legumes—clovers, peas, beans, vetches, etc.—resent even small amounts of either. The entire sunflower family is rather tolerant of alkali, while most of the cultivated grasses proper are quite sensitive, if only because their shallow rooting exposes them peculiarly to the evil effects of the surface accumulation of alkali by evaporation.

Nearly 200 species of plants native to California which will grow only on alkali soils have been studied. It appears that many of these are restricted to soils in which a certain salt predominates, and in such soils these plants often grow almost to the exclusion of other species, thus furnishing a means of judging of the kind of soil underlying them as well as of its reclaimability and adaptations. As a result of the studies along this line by the California Station, the alkali soils of California have been divided into distinct belts, or zones, each characterized by a single species of plant. The different belts, together with the amount of the various alkali salts found by analysis of the soils, are shown in the accompanying table:

Pounds of alkali salts per acre in one foot of soil from the different belts.

Belt.	Sulphates.		Carbonates.		Chlorids.		Total salts.	
	Min.	**Max.**	**Min.**	**Max.**	**Min.**	**Max.**	**Min.**	**Max.**
	Pounds.	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*
Scrub saltbush (*Atriplex polycarpa*)	Trace.	37, 880	240	19, 000	None.	21, 360	840	78, 240
Bushy golden-rod (*Bigelovia veneta*)	680	15, 360	None.	7, 480	None.	3, 720	1, 800	24, 320
Saltwort (*Suæda* sp.)	36, 000	176, 000	360	24, 240	26, 000	105, 800	74, 480	306, 040
Fine-top salt-grass (*Sporobolus airoides*)	3, 440	98, 920	680	13, 480	360	55, 680	6, 600	155, 280
Greasewood (*Allenrolfea occidentalis*)	7, 440	146, 000	160	3, 400	10, 400	85, 880	27, 320	194, 760
Samphire (*Salicornia* sp.)	55, 320	176, 000	320	24, 240	5, 560	105, 800	61, 240	306, 040

Both Bigelovia and scrub saltbush indicate, as far as the data at present at hand permit us to determine, a light, gravelly soil, with comparatively low alkali contents, chiefly composed of sulphates. The minimum of sulphates is lowest and the maximum highest in the scrub saltbush belt, but carbonates ("black alkali") and chlorids are lowest in the Bigelovia belt.

Samphire indicates moist soil, with excessive chlorids (common salt) and sulphates.

Greasewood (Allenrolfea) grows only, as far as our data show, in moist soil, where sulphates and common salt are heavy and carbonates light.

Saltwort (Suæda) depends on heavy chlorids and heavier sulphates, with carbonates varying between 360 and 24,000 pounds to the acre. It evidently tolerates the latter considerably, without preferring them.

Much work has yet to be done before we can determine the full extent of the value of these and other plants as alkali indicators.

Of these belts, only the first two seem favorable to reclamation, although the others will grow plants well adapted to grazing. Finetop salt-grass is readily eaten by cattle, and the recently introduced Australian saltbushes seem quite promising for soils containing large quantities of alkali. The following preliminary list of plants suitable for cultivation on alkali soils is given:

On strong alkali.—Saltbushes (*Atriplex* spp.), fodder plants; Modiola (*Modiola decumbens*), fodder; wild millet (*Beckmannia erucæformis*), fodder; *Kolreuteria paniculata*, shrub; sac-saoul (*Haloxylon ammodendron*), dwarf timber, valued for fuel; *Salsola soda* and *S. indica*, formerly burned for barilla, used in the manufacture of glass and soap; Kochia (*Kochia* spp.), fodder plants.

Apparently not tolerant of the strongest alkali.—Vegetables—Sunflower (*Helianthus annuus*), used for chicken feed, oil, paper, and fuel; valuable for hogs; beets (garden and sugar), spinach, onion, celery, and asparagus; fruits—*Elæagnus angustifolius*, a tree with small and agreeable fruit, and Peruvian ground-cherry (*Physalis peruviana*), Jerusalem artichoke (*Helianthus tuberosus*), especially the white variety, herb, with an edible fruit; and fodder plants—slender grass (*Leptochloa imbricata*), Johnson grass (*Andropogon halepense*), quack grass (*Agropyron repens*), switch grass (*Panicum virgatum*), smooth bunch grass (*Poa lævigata*), wild rye (*Elymus condensatus*), alkali saccatone (*Panicum bulbosum*), redtop (*Agrostis alba*), Bermuda grass (*Cynodon dactylon*), jointed barley grass (*Hordeum nodosum*), tea tree (*Leptospermum lanigerum*), an Australian shrub, and Myall (*Acacia pendula* and *A. homalophylla*), shrubby acacias.

INFLUENCE OF ALKALI ON THE GERMINATION AND GROWTH OF PLANTS.

In experiments by the Wyoming Station on the influence of alkali salts on the germination of wheat and rye, it was found that small amounts of these salts hasten germination and no doubt also "assist in the life of the plant, either stimulating its growth or acting directly as plant food." When, however, the proportion of alkali salts exceeded certain limits, germination was interfered with. The amounts of the different salts which may be present without interfering with the germination of wheat and rye were found to be as follows:

Amounts of different salts which may be present without retarding germination of wheat and rye.

	Magnesium sulphate.		Sodium sulphate.		Sodium chlorid.		Sodium carbonate.	
	In solution.	In soil.	In solution.	In soil.	In solution.	In soil.	In solution.	In soil.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Wheat	1.0	0.25	0.7	0.17	0.4	0.1	0.4	0.10
Rye	1.0	.25	.7	.17	.4	.1	.1	.02

It did not appear that any of the salts, except sodium carbonate, exerted directly poisonous or corrosive effects on the seeds. The injury appeared to be due to the fact that the salts in solution interfered with the absorption by the seed of the water necessary for germination.

The experience of the Wyoming Station indicates that there are "very few useful plants which will grow where the soil contains so much alkali that an incrustation is formed on the surface."

Incrustation of ordinary white alkali on the surface is usually marked, at least during dry weather, where there is as much as 1½ or 2 per cent of salts in the first 2 inches of soil. Such an amount of salts will prevent the growth of any of the cereals or of alfalfa. Barley and rye seem to stand more alkali than wheat or oats. Barley, rye, or alfalfa will probably grow in the presence of as much as 1 per cent of ordinary white alkali (sulphates of soda and magnesia) in 2 inches of surface soil, providing the water level is not nearer the surface than 2 or 3 feet. Usually where there is so much alkali as this, which has accumulated from irrigation above, the water comes near the surface, leaving the soil saturated most of the time. Where this occurs less than 0.5 per cent of salt along with the water is fatal to such crops. Upon soils containing about 2 per cent of salts in the first 2 inches we have tried, without success, rye, wheat, barley, oats, alfalfa, and Russian sunflowers. Brome grass and redtop have been partially successful.

Among other alkali-resisting plants which the station has successfully tested are saltbushes (*Atriplex* spp.), English rape, Bokhara or white sweet clover, and sugar beets.

THE FEEDING VALUE OF THE CORN PLANT AT DIFFERENT STAGES OF GROWTH.

On the greater number of farms, especially in those sections of the country where large acreages are cultivated by individual farmers, the corn crop is grown mainly for the grain. The ears are husked and cribbed, while the stalks are left in the field. During the winter the cattle usually feed on the stalks, and what is not eaten by them is left to decay on the ground. This method of feeding is practiced mainly because the stalks are plentiful and are fed with the least trouble in this way, and the food value of the plant after the ear has been removed is considered insignificant. On many farms, especially where farming is carried on somewhat intensively, the corn crop is cut for fodder or made into silage. When the dry season has caused a scarcity of hay corn fodder makes a most excellent substitute. The feeding value of the fodder is appreciated by many farmers, and circumstances, such as a scarcity of feeding stuffs, may force others to cut their corn and put it up as fodder in order to feed it in an economical way. The greatest difficulty in securing corn fodder is the amount of labor and time required to cut and shock it; but the corn harvester, which has come into use during recent years, has lightened this burden to a great extent and the main work now is in building the shock. The greater rapidity with which the work can now be done makes it possible to cut larger fields at the proper time.

In this connection the composition of the leaves and the stalks as the plant approaches maturity becomes a significant factor. The food value of the fodder depends largely upon the time of cutting, and after that upon the curing and storing. A study of the distribution of food material in the leaves, stalks, and ears at different stages of growth was begun by the Michigan Experiment Station in 1896 and partially repeated in 1897. The results of this investigation have been published in a recent bulletin in connection with other data.

The first year of the experiment 100 representative stalks were selected at each of four different dates, namely, August 24, when the corn was in the milk; August 31; September 7, when the corn was glazing, and September 14, when it was ripe. The weight of the leaves, stalks, and ears, and the percentage of the total weight each represented were determined as given below:

Weight of the leaves, stalks, and ears of 100 corn plants and the percentage of the total dry matter contained in these parts at different stages of growth.

Time of cutting.	Weight.				Percentage of total weight.			Percentage of total dry matter.		
	Entire plant.	Leaves.	Stalks.	Ears.	Leaves.	Stalks.	Ears.	Leaves.	Stalks.	Ears.
	Lbs.	*Lbs.*	*Lbs.*	*Lbs.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
August 24 (in milk)	201.75	85.0	67.75	49.00	42.13	33.57	24.30	36.41	34.27	29.32
August 31	195.00	76.0	66.50	52.50	38.98	34.10	26.92	33.63	25.52	40.85
September 7 (glazing)	210.25	82.0	69.50	59.75	39.00	33.66	27.34	30.03	25.53	44.44
September 14 (ripe)	176.50	49.5	64.00	63.00	28.04	36.26	35.70	21.77	31.91	46.32

From a feeding point of view the total weight of the plant is of less importance than the amount of dry matter contained in the plant. As is shown by the figures in the above table, the relation of the weight of the stalk to the entire plant remained very nearly constant, while the relative weight of the ear increased and that of the leaf decreased. When the plant was fully matured less than one-half of the total dry matter was in the ear, about one-third in the stalk, and more than one-fifth in the leaves. When the corn was in the milk a little over one-third of the food material was contained in the leaves, a slightly smaller proportion in the stalks, and still less in the ears. A week later, when the plant had reached what is commonly known as the roasting-ear stage, the leaves still contained more than one-third of the dry matter, but only about one-fourth of it was found in the stalks, while the ears now contained a little over 40 per cent. This is regarded as evidence that the ears grew partially at the expense of the stalk. At the glazing period the leaves contained less than one-third of the total dry matter of the crop, the stalks about one-fourth, and the ears over 44 per cent; but when the corn was fully ripe and ready to be harvested there was still over 53 per cent of the dry matter in the stalks and leaves and but 46.32 per cent in the ears.

A further study was made of the distribution of the protein and albuminoids (nitrogenous constituents, see p. 30) and the nitrogen-free extract (containing especially the carbohydrates, starches, sugars, etc., see p. 31). The results obtained in this investigation are given in the following table:

Distribution of protein, albuminoids, and nitrogen-free extract in the leaves, stalks, and ears of the corn plant at different stages of growth.

Time of cutting.	Protein.			Albuminoids.			Nitrogen-free extract.		
	Leaves.	Stalks.	Ears.	Leaves.	Stalks.	Ears.	Leaves.	Stalks.	Ears.
	Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
August 24 (in milk)	52.70	16.00	31.30	52.50	10.00	37.50	38.50	17.50	44.00
August 31	44.69	10.96	44.35	51.06	2.53	46.41	28.40	23.64	47.96
September 7 (glazing)	40.62	9.38	50.00	42.71	5.19	52.10	20.50	25.30	54.20
September 15 (ripe)	32.30	17.10	50.60	30.60	10.70	58.70	15.90	29.40	54.70

The results show that in the earlier stages the greater portion of the protein, which is the most valuable single nutrient, was located in the leaves, and even when the corn had sufficiently matured for cutting only a little over half of it was found in the ears. About 60 per cent of the albuminoids, the most valuable part of the protein, and over half of the nitrogen-free extract (carbohydrates, starch, sugar, etc.) were found in the ears at the time of the last analysis. When the corn was fully ripe, about twice as much starch and sugar was found in the stalks as in the leaves.

In 1897 the work was partially repeated and the results were analogous to those obtained the year before. This season there was apparently a slight loss in the total dry matter between September 6 and September 15, but at the same time there was a gain of dry matter in the ears and a corresponding loss in the leaves and stalks.

During 1896 investigations were also made on the distribution of the food materials in sweet corn and sorghum. It was found that the ears of sweet corn when the plant is fully ripe contain but little more than one-half of the total dry matter, the leaves over one-fourth, and the stalks less than one-fifth. In this case, as in the case of the dent corn, the leaves included the husks. When the corn was ripe the leaves contained 23.80 per cent of the protein and 36.60 per cent of the albuminoids. The ears contained over 60 per cent of the total protein and were also found to be rich in the carbohydrates—starch, sugar, etc.—but not relatively so rich in these constituents as in protein.

In the study of sorghum the greater portion of the dry matter of the plant was found in the stalks, and when the plant was ripe the amount of dry matter in the leaves was about equal to the amount contained in the tops. Although over 65 per cent of the total dry matter was found in the stalks, 45.56 per cent of the protein was found in the leaves and less than 20 per cent in the stalks. The albuminoids were found to be distributed as follows: 39.33 per cent in the leaves, 36.38 per cent in the tops, and 24.29 per cent in the stalks. Nearly three-fourths of the carbohydrates—starch, sugar, etc.—was found in the stalks. The analyses show that the leaves and heads of sorghum are relatively rich in protein.

In connection with these experiments the absolute weight of dry matter and nutrients was determined in 400 hills of corn cut on different dates and from these data the yields of dry matter and nutrients per acre were calculated. The results were as follows:

Yields per acre of green fodder, dry matter, and nutrients.

Time of cutting.	Green fodder.	Dry matter.	Protein.	Nitrogen-free extract.	Fat.	Fiber.
	Pounds.	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*
August 10 (tasseled)	21, 203	3, 670. 24	472. 73	1, 828. 15	67. 90	1, 010. 05
August 25 (in milk)	25, 493	5, 320. 39	576. 08	3, 212. 45	143. 11	1, 148. 67
September 6 (glazing)	25, 865	7, 110. 29	711. 03	4, 554. 14	199. 08	1, 294. 78
September 15 (ripe)	23, 007	8, 020. 24	696. 96	5, 356. 72	242. 61	1, 413. 17

The gross weight of the crop increased rapidly and regularly up to the time of glazing. After that period the change was mainly in the displacement of water by dry matter. From the tasseling of the corn to the time when the ears were in the early roasting stage there was a gain of 44 per cent in the dry matter; from the early roasting stage to the time of glazing the dry matter increased over 33 per cent, and from this stage up to maturity there was a further increase of about 12 per cent. The albuminoids and the protein increased rapidly up to the time the kernels were glazed. The increase in nitrogen-free extract and fat from the beginning of glazing to maturity was more than one-sixth and one-fifth, respectively. From these results it is concluded that in order to secure the greatest yields of dry matter and available nutrients the corn should not be harvested until fully glazed and until some of the earlier ears are nearly, if not quite, ripe.

SOWS AND PIGS AT FARROWING TIME.

The Wisconsin Station has recently published some interesting data concerning sows and pigs at farrowing time. The weight of the sows before and after farrowing was recorded, as well as the weight of the erbirth, and the weight of each pig at birth.

The sows on which observations were made were ten in number and were pure-bred Poland-Chinas and Berkshires, crosses of these breeds, or cross-bred Poland-China-Chester Whites. They ranged in age from one to four years, and in weight from 240 to 577 pounds. The average weight before farrowing was 382.1 pounds; after farrowing, 359 pounds. The average weight of the afterbirth was 4.01 pounds. The litters averaged 16.7 pounds each. The individual pigs ranged in weight from 1.3 to 3.1 pounds, the average being 2.2 pounds. There were from 5 to 12 pigs in a litter, and in general the individual pigs in large litters were somewhat smaller than those in small litters.

In a litter of pigs there is often one much weaker than the others. This is often called the runt, or teatman. It is frequently spoken of as the last pig farrowed, this occurrence being supposed to cause inferiority. This idea was not borne out by the facts observed. The first pig born in one of the lots weighed 2.1 pounds, and the last 2.6 pounds. In other cases the pig farrowed last weighed less than the one farrowed first. In this matter, however, no regularity was observed, and it is stated that no weakness or other inferiority was observed in the last pig farrowed.

THE SOY BEAN AS A FEEDING STUFF.

The soy bean, an annual leguminous plant, has been grown from the earliest times in Japan, China, and other countries of southeastern Asia. It is said to have been introduced into this country from Japan in 1854, but for a long time it was cultivated to only a limited extent, principally in the South. In comparatively recent years, however, improved varieties, adapted to varying climatic conditions, have been introduced, and the cultivation of the plant has spread quite rapidly, its range of successful culture being almost as wide as that of corn. Many of the stations have experimented with the bean and thus called attention to its merits, and the Division of Agrostology of this Department has issued a Farmers' Bulletin (58) which discusses in detail the characteristics, varieties, and culture of the plant and its value as a food and feeding stuff.

The Japanese and other Orientals grow the plant mainly for the seed which are used in the preparation of a variety of foods. The bean is rich in nutritive material and makes a valuable food. It has a high protein content, and hence serves well to balance the diet of people, such as the Japanese, who do not eat much meat. There is no special demand for such a food in this country, however, and so the soy bean is likely to be, at least for many years to come, of most value as a feeding stuff. It serves admirably to balance the rations fed to stock. The plant may be fed as green fodder, hay, or silage; or the beans may be fed in the form of meal. As a green fodder it has been fed at several stations with varying success. It seems that stock in many cases does not relish it at first, but becomes accustomed to it.

The food constituents in the soy bean and in corn and some other feeding stuffs are shown in the following table of average analyses:

Food constituents in soy beans as compared with other feeding stuffs.

	Water.	Ash.	Protein.	Fiber.	Nitrogen-free extract.	Fat.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Green soy bean (whole plant)	75.1	2.6	4.0	6.7	10.6	1.0
Green corn fodder	79.3	1.2	1.8	5.0	12.2	.5
Soy-bean hay (with pods and seeds)	11.3	7.2	15.4	22.3	[illegible].6	5.2
Dry corn fodder (with ears)	42.2	2.7	4.5	14.3	34.7	1.6
Soy-bean straw (after thrashing)	10.1	5.8	4.6	40.4	37.7	1.7
Corn stover (plant without ears)	40.5	3.4	3.8	19.7	31.5	1.1
Soy-bean seed	10.8	4.7	34.0	4.8	28.8	16.9
Corn kernels	10.9	1.5	10.5	2.1	69.6	5.4
Soy-bean meal	10.8	4.5	36.7	4.5	27.3	16.2
Pea meal	10.5	2.6	20.2	14.4	51.1	1.2
Corn meal	15.0	1.4	9.2	1.9	68.7	3.8
Cotton-seed meal	8.5	7.2	43.3	5.4	22.3	13.5
Linseed meal (new process)	10.1	5.8	33.2	9.5	38.4	3.0
Soy-bean silage	74.2	2.8	4.1	9.7	6.9	2.2
Clover silage	72.0	2.6	4.2	8.4	11.6	1.2
Corn silage	79.1	1.4	1.7	6.0	11.0	.8
Soy bean and corn silage	76.0	2.4	2.5	7.2	11.1	.8
Soy bean and millet silage	79.0	2.8	2.8	7.2	7.2	1.0

It will be readily seen from the above table that the soy bean is very rich in nutritive materials, the green plant being much richer than green-corn fodder and the ripe seed than corn kernels. In fact the composition of the seeds more closely approaches that of the oil cakes—cotton-seed meal, linseed meal, etc.—than any other class of feeding stuffs. It has been shown by the Massachusetts Station, however, that with the yields usually obtained in that section corn produces a larger amount of nutritive material per acre than the soy bean. The latter, however, has the following advantages: "(1) It can draw much of its nitrogen from the air; (2) the bean stubble and roots probably have greater manurial value than those of corn; and (3) the bean, being so rich in flesh formers [protein], may take the place of such concentrated foods as cotton-seed meal, linseed meal, gluten meal," etc. As the analyses show, the hay, like that of other leguminous plants, is rich in protein. The plant is likely to lose a large part of its leaves in the process of curing and thus suffer a serious reduction in nutritive value.

The value of this crop for silage is recognized. It is highly nutritive, gives a heavy yield, and is easily cultivated. The vigorous late varieties are well adapted for silage. The crop is frequently ensiled with corn (2 parts of the latter to 1 of the former), and like other legumes it improves the silage by tending to counteract the acid reaction of corn silage.

Soy-bean meal is a highly nutritious feeding stuff. An experiment conducted at the Massachusetts Hatch Station led to the conclusion that soy-bean meal is a better feeding material for dairy cows than cotton-seed meal. The soy-bean meal produced more milk, richer cream, and better butter.

The Kansas Station has probably experimented with the soy bean more extensively than any other station. Its experience with the soy bean as a food for stock is reported as follows:

> With dairy cows soy-bean meal takes the place of linseed meal, being somewhat richer in protein, a laxative feed, and softening the butter fat. Not over 3 pounds per day should be fed to a cow, and the softening effect on the butter may be overcome by giving feeds having the opposite tendency, such as corn, Kafir corn, and cotton-seed meal.
>
> In the winter of 1898, in fattening 7½-months-old pigs, the gains per bushel of feed were:
>
> | | Pounds. |
> |---|---|
> | Kafir-corn meal | 11.7 |
> | Shelled corn | 12.3 |
> | Kafir-corn meal four-fifths, soy-bean meal one-fifth | 13.9 |
> | With pigs 6 months old the gains per bushel of feed were: | |
> | Kafir-corn meal | 9.4 |
> | Shelled corn | 11.2 |
> | Kafir-corn meal four-fifths, soy-bean meal one-fifth | 13.2 |
>
> With both lots the pigs having soy-bean meal made the most rapid growth and were ready for market much earlier.
>
> With weaning pigs the gains per bushel of feed were:
>
> | | Pounds. |
> |---|---|
> | Kafir-corn meal | 10.4 |
> | Corn meal | 11.5 |
> | Kafir-corn meal two-thirds, soy-bean meal one-third | 15.4 |
> | Corn meal two-thirds, soy-bean meal one-third | 15.6 |
>
> In the fall of 1898 this station bought of farmers 60 ordinary stock hogs of mixed breeds. The gains per bushel of feed in fattening these hogs were:
>
> | | Pounds. |
> |---|---|
> | Kafir-corn meal | 7.5 |
> | Kafir-corn meal four-fifths, soy-bean meal one-fifth | 12.0 |
>
> The hogs fattened with soy-bean meal have just been marketed, while those not having it will not be ready for four or five weeks.

ALFALFA HAY FOR HOGS.

The Kansas Experiment Station has recently reported the results of experiments made during the fall of 1898 to test the value of alfalfa hay fed to pigs receiving all the grain they would eat.

The pigs, averaging 125 pounds each, were placed in lots of ten in large pens provided with shelter sheds open to the south. Alfalfa hay of the best quality was fed dry in a large flat trough, the pigs receiving in addition all the black-hulled white Kafir corn they would eat without waste. The animals were given more hay than they would eat and they consumed only the leaves and finer stems. Beginning November 24 and continuing nine weeks one lot of pigs was fed alfalfa hay and Kafir-corn meal dry; a second lot, Kafir corn dry; a third lot, Kafir-corn meal dry; and a fourth lot, Kafir-corn meal wet.

The gains per hog in the nine weeks from the different methods of feeding were as follows:

	Pounds.
Kafir-corn meal dry and alfalfa hay	90.9
Kafir corn whole	59.4
Kafir-corn meal fed dry	52.4
Kafir-corn meal fed wet	63.3

At the end of the experiment the alfalfa-fed pigs were well fattened and were marketed. It is estimated that under normal conditions it would have taken four or five weeks longer to put the other lots into good marketable condition.

The gain from feeding alfalfa hay with Kafir-corn meal fed dry, over the meal alone fed dry, was more than 73 per cent.

Ten hogs in nine weeks were fed 656 pounds of alfalfa hay; and for each 7.83 pounds of alfalfa hay fed with the dry Kafir-corn meal the hogs gained 3.4 pounds over those having dry Kafir-corn meal alone—a gain of 868 pounds of pork per ton of alfalfa hay. These results are not due to the feeding value of the alfalfa alone, but also to its influence in aiding the hogs to better digest the Kafir corn. The alfalfa hay also gave a variety to the ration, making it more appetizing and inducing the hogs to eat more grain. The ten hogs having grain alone ate 3,885 pounds of dry Kafir-corn meal, while the ten hogs having hay and grain ate 4,679 pounds of the Kafir-corn meal and 656 pounds of alfalfa hay. The hay-fed hogs ate more grain and gained more for each bushel eaten.

In a former experiment at this college, pigs were pastured through the summer on alfalfa with a light feeding of corn. After deducting the probable gain from the corn, the gain per acre from the alfalfa pasture was 776 pounds of pork.

These facts indicate that to produce pork most cheaply the Kansas farmer must have alfalfa pasture in summer and alfalfa hay in winter.

ANIMAL MATTER A NECESSITY FOR POULTRY.

It is well known that poultry when allowed to range at will eat considerable quantities of animal matter in the form of insects, worms, etc.

How necessary this animal matter is to the health of fowls, and especially ducks, was strikingly brought out by recent experiments at the New York State Experiment Station. Two lots each of chickens and ducks, as nearly alike as possible, were used in these experiments. One lot in each case was fed a ration of mixed grains and skim milk or curd containing no animal matter, the other a ration of mixed grains, with animal meal and fresh bones or dried blood. The two rations were about equally well balanced, although the "animal-matter" ration contained a little less protein than the "vegetable-matter" ration. The distinctive difference between the two rations was that in the one case two-fifths to one-half of the protein came from animal sources, while in the other it all came from vegetable sources.

Two trials were made with chickens.

In each trial more food was eaten by the lot receiving animal protein, the gain in weight was more rapid, maturity was reached earlier, less food was required for each pound of gain, and the cost of gain was less.

During the first twelve weeks of the first trial [starting with chickens one-half week old] the chicks on animal meal gained 56 per cent more than those on the vegetable diet, although they ate only 36 per cent more; they required half a pound less of dry matter to gain 1 pound and each pound of gain cost only 4½ cents, as compared with 5½ cents for the grain-fed birds.

During the next eight weeks the cost of gain was 7½ cents and 11½ cents, respectively. The animal-meal chicks reached 2 pounds in weight more than five weeks before the others; they reached 3 pounds more than eight weeks sooner, and three pullets of the lot began laying four weeks earlier than any among the grain-fed birds.

With the second lot of chicks, starting at six weeks of age, the differences were in the same direction, though not quite so striking, thus showing that the great advantage of the animal nitrogen is in promoting quick, healthy growth and early maturity rather than increasing the tendency to fatten. * * *

The results were most convincing, almost startling, in the case of ducklings fed the contrasted ration. * * * Before the experiment had been long under way it was noticed that the animal-meal birds were developing rapidly and evenly, but the grain-fed ducklings were becoming thin and uneven in size. It was sometimes almost pitiful to see the long-necked, scrawny, grain-fed birds, with troughs full of good, apparently wholesome food before them, standing on the alert and scrambling in hot haste after the unlucky grasshopper or fly which ventured into their pen, while the contented-looking meat-fed ducks lay lazily in the sun and paid no attention to buzzing bee or crawling beetle. The 32 meat-fed birds lived and thrived, but the vegetable-food birds dropped off one by one, starved to death through lack of animal food, so that only 20 of the 33 were alive at the close of the fifteenth week of contrasted feeding. They were then fed for four weeks on the meat-meal ration and made nearly as rapid gains as the other lot at the same size two months before, but they never quite overcame the disadvantage of their bad start on grains alone. * * *

In conclusion, then, it may be said that rations in which from 40 to 50 per cent of the protein was supplied by animal food gave more economical results than rations drawing most of their protein from vegetable sources. The chief advantage was in the production of rapid growth, although the cost of production is also in its favor. While inferior palatability may have had something to do with the marked results, especially with the ducks, the whole bearing of these experiments and others not yet reported seems to indicate that the superiority of the one ration is due to the presence in it of animal food.

RELATION OF WATER SUPPLY TO ANIMAL DISEASES.

About three-fifths of the animal body is water, and while water is not strictly a food in itself, no food can be assimilated without the aid of water, large quantities of it being required to carry on this process. According to a bulletin of the Indiana Station—

The horse requires from 64 to 80 pounds, or 8 to 10 gallons per day, a gallon of water weighing 8 pounds. During the months of February and March five horses drank from 48 to 60 pounds per head when not at work, and from 62 to 84 pounds while at work. Forty-four per cent of the water was drunk in the forenoon and 56 per cent in the afternoon.

Cattle drink more than horses. During the period above referred to, cows not giving milk drank 78 pounds and cows in full flow of milk drank 112 pounds per day. The largest drink was 122 pounds, and the greatest amount taken by one animal in one day was 176 pounds. The Utah Experiment Station found that steers feeding upon dry feed required 83 pounds of water per day, while those fed upon green food consumed only 33 pounds per day. Cattle drank 72 per cent of water in the morning and 28 per cent in the evening.

Pigs fed corn and skim milk (3 pounds per day) drank 2.65 pounds of water per day; those fed wheat and skim milk, 5.2 pounds; those fed corn, wheat, and skim milk, 3.9 pounds; those fed soaked wheat and skim milk, 5.3 pounds. These figures indicate, as in the experiments with steers at the Utah Station, that the amount of water drunk is influenced to a considerable extent by the character of the food.

No attempt has been made to determine the quantity of water needed daily for sheep. * * * They drink comparatively little water while upon pasture. They can endure privation as regards water far beyond other domestic animals. This has led to the belief common among farmers that sheep do not need water and that dew is sufficient. This is a serious mistake, and accounts for the loss of many hundred lambs in this State every year.

The number of times an animal will drink during the day, when allowed full opportunity, is not known, but is indicated in a general way by the stomach. The stomach of the horse is small and, as might be supposed, does not require much water at a time, but often. The stomach in cattle is very large, and rumination (chewing the cud) is performed. This necessitates saturating the food with water before rumination can take place, and probably explains why so much water is drunk in the morning.

The above facts make it clear that we may expect a close and important relationship between water supply and disease in domestic animals, and this fact is most strikingly demonstrated when the supply is insufficient or is contaminated with matter which causes disease.

The diseases which arise as a result of supplying water in insufficient quantities or not providing water in accessible places are sporadic in character; that is, affect only an occasional animal, or a few in a herd or flock. Probably the most serious disease having such cause is mad itch in cattle. This occurs especially in the fall of the year, when the cattle are upon dry pasture or when turned in upon a dry stalk field. It may occur at other times, and also be due to other causes, but without doubt 90 per cent of the cases occurring in this State are directly traceable to this cause. Sheep also suffer from impaction and constipation, and large numbers die for want of proper water supply. Hogs, especially young ones, often succumb from like treatment. Horses probably suffer least loss, because they receive the greatest care in this respect, but no doubt many cases of colic, impaction, and constipation are traceable to this source.

The losses that arise from an insufficient water supply are small compared with those caused by water of an improper character. Water which comes from deep wells, properly protected, is free from disease germs; that, however, which comes from ponds, ditches, and streams may contain such germs. "Not all surface waters are dangerous, but all are more or less exposed to infection, and may become dangerous at any time."

Careful investigation has shown that hog cholera has been largely disseminated in Indiana by contaminated streams, thus bearing out the conclusions from investigations by the Bureau of Animal Industry of this Department that "perhaps the most potent agents in the distribution of hog cholera are streams. * * * The first step to be taken in the prevention of hog cholera is the securing of a wholesome water supply."

There are numerous parasitic diseases to which all animals are subject. Water is necessary to the growth of these and is an important carrier of them. Such parasitic diseases as twisted stomach worms, nodular disease, paper skin, liver fluke, and lung worm of sheep, and worms in hogs, horses, and cattle, are largely due to surface water. "Pure water from deep wells is the preventive."

COOLING OF CHEESE-CURING ROOMS.

The importance of properly constructed cheese-curing rooms, with provision for regulating the temperature, was emphasized in the report of the Wisconsin Experiment Station for 1897, and a more recent bulletin of the station gives practical recommendations on this point:

> The watchful eye of the maker is too often diverted from the cheese as soon as it is placed upon the shelves. Inspection of the conditions under which cheese is cured in this country almost without exception shows that the details of the curing process receive little or no attention. Curing rooms are built in the cheapest possible manner. No attempt is made to control the temperature or the moisture content of the same. It is not at all uncommon to find cheese stored in places the temperature of which is subject to almost as much fluctuation as the outside air.

The result is not only a temperature far too high for proper cheese ripening, but sudden fluctuations in the temperature, which are extremely undesirable. The effect of the high temperatures is very deleterious to the quality of cheese, resulting in the melting and leaking out of the fat and a serious injury to the texture and flavor of the cheese. This was demonstrated by the station in a series of experiments, in which cheese was cured under conditions which ordinarily prevail at cheese factories in the State, and also in rooms where the temperature was carefully controlled. The cheese cured at a high temperature "had a rank flavor and a value not exceeding 3 or 4 cents a pound," whereas the cheese cured at 55° F. and below was invariably of good quality and entirely free from all bitter flavor, and was rated by an expert at 7¾ cents. The limit to the safety zone is said to be about 65° F., and a temperature of from 65° to 75° is regarded as hazardous, while a temperature above 75 degrees is regarded as invariably detrimental.

No matter how carefully an above-ground curing room has been constructed, if the temperature is to be held below 65° it must be artificially cooled by some method. This may be effected by (1) ventilating with night air, (2) ventilating through horizontal subearth ducts, (3) ventilating through deep vertical subearth ducts and wells, (4) the use of cold water, (5) ventilating over ice, (6) evaporation of water, and (7) mechanical refrigeration. The bulletin considers only the first three methods.

COOLING BY VENTILATING WITH NIGHT AIR.

Where rooms are cooled by ventilating with night air, some means must be adopted for forcing the air into and out of the rooms. The simplest means is the use of a 10-inch galvanized-iron flue, rising from the curing room not less than 15 feet above the ridge of the roof of the factory and terminating in a wind funnel. While night ventilation is an improvement over no effort to control the temperature, it is not believed that it will give the best results.

COOLING BY VENTILATING THROUGH HORIZONTAL SUBEARTH DUCTS.

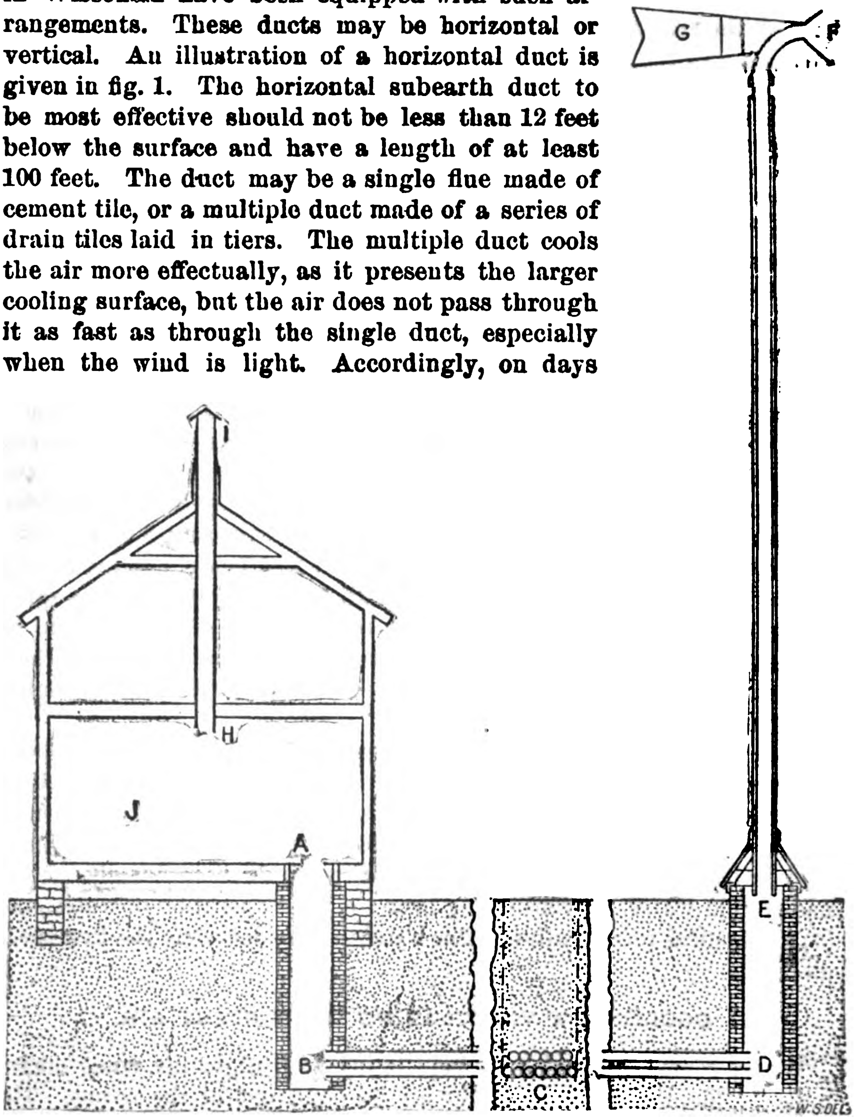


Fig. 1.—Section of cheese-curing room and horizontal multiple subearth duct: A, inlet to curing room; B, end of subearth duct in bricked entrance to factory; C, cross section of the multiple ducts; D, E, bricked entrance under funnel at outer end of subearth duct; F, funnel with mouth 36 inches across; G, vane to hold funnel to the wind.

Professor King, of the station, has given considerable study to cooling by means of subearth ducts, and as a result of his work several factories in Wisconsin have been equipped with such arrangements. These ducts may be horizontal or vertical. An illustration of a horizontal duct is given in fig. 1. The horizontal subearth duct to be most effective should not be less than 12 feet below the surface and have a length of at least 100 feet. The duct may be a single flue made of cement tile, or a multiple duct made of a series of drain tiles laid in tiers. The multiple duct cools the air more effectually, as it presents the larger cooling surface, but the air does not pass through it as fast as through the single duct, especially when the wind is light. Accordingly, on days when the wind is light the multiple duct may not be as effective as the single duct of the same total cross section and length. Professor

King recommends either three rows of 10-inch tile or five rows of 8-inch tile. The cost would be about the same in both cases. The tile may be placed side by side, or the trench may be dug narrower and a foot or two deeper and the tile placed one above the other. The flue for conducting the air from the funnel to the duct may be made of plank with the inside opening 12 inches square, or of galvanized iron with a diameter of 12 inches. The latter is considered preferable, as it is not so likely to leak air. Fifty feet in height is considered sufficient for this flue unless there are obstructions to the wind. The construction of the funnel is shown in fig. 2.

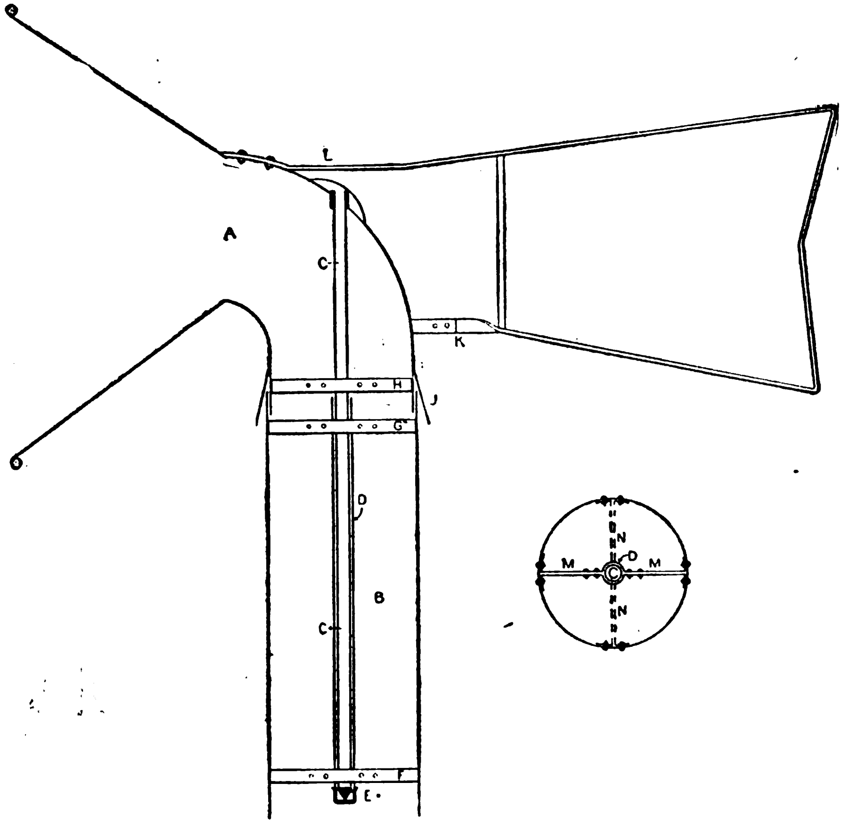


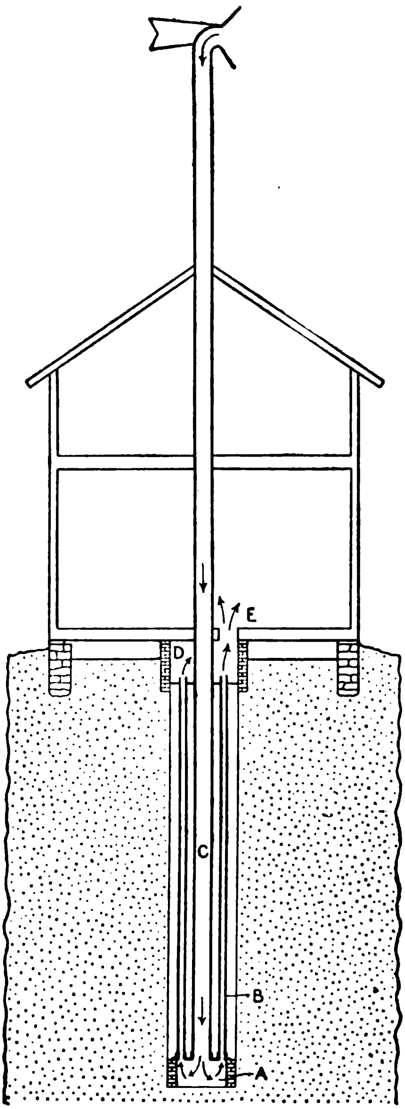
FIG. 2.—Showing how funnel and vane may be mounted: A, funnel; B, shaft of funnel; C, C, C, 1-inch gas pipe; D, D, 1¼-inch gas pipe; E, cap for support of 1-inch gas pipe; F, G, H, and M M and N N are stays of band iron bolted together and to the sides of the shaft to support the axis of the funnel; J, weather collar to turn rain out of shaft; K, L, band iron to stiffen vane and attach it to funnel.

COOLING BY VENTILATING THROUGH DEEP VERTICAL SUB-EARTH DUCTS.

If it is possible to go down some distance before striking water, vertical ducts may be successfully used. These require less piping, which will reduce the friction and hence give a greater current in lighter winds than in the case of long horizontal ducts. It is recommended to make the vertical duct not less than 25 or 30 feet in depth if practicable. Its construction is shown in fig. 3. An ordinary well is dug about 40 inches in diameter, with the large inlet pipe in the center and surrounded by thirteen lines of 6-inch drain tile or 5-inch galvanized iron pipe, the earth being closely packed between the different lines of pipe. The upper end of this system of pipes leads into a chamber which communicates directly with the curing room. In practical experience in a cheese factory in Wisconsin a well 64 feet deep used as a subearth duct was found to be quite efficient. Professor King believes that the closed well will be found more serviceable than the open well, and more effective than the much longer horizontal ducts which have been built.

COOLING THE SOIL FOR SHORT DUCTS.

Where it is impracticable to go deeper than 15 or 20 feet without striking water, the well may be constructed as just described, and the space between the air flues filled in with sandy soil or fine sand and this cooled by pumping cold water from the well upon it once a week or oftener. Where this is done, galvanized iron flues are preferable to drain tile, which will allow



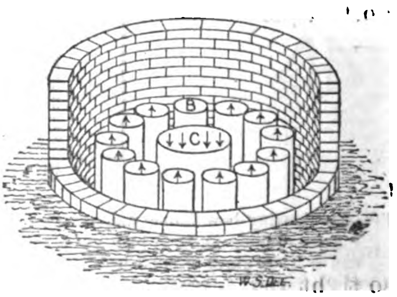


FIG. 3.—Showing vertical subearth duct: A, brick chamber 25 to 30 feet below surface and 40 inches inside diameter; B, tile or conductor pipe of galvanized iron; C, main shaft of funnel; D, brick chamber at upper end of duct.

water to percolate into them. The bottom of the duct should be at least 4 feet above standing water in the ground, so as to give good drainage.

COOLING WITH AIR FORCED THROUGH COLD WATER.

Where the ground water is so close to the surface that a vertical duct could not be made more than 12 or 15 feet deep, a cistern about 5 or 6 feet in diameter may be constructed and the air cooled by passing it through a system of pipes in the cistern, as shown in fig. 4. The flue for introducing the air runs down to the bottom of the cistern, where it connects with an air-tight drum, into which are soldered 13 or more 5-inch flues of galvanized iron, 10 feet long, which communicate with a second drum at the surface of the cistern. The air passes down through the center flue, is distributed to the 13 or more pipes, which are surrounded by water, and rises to the upper drum, from which it is led into the curing room. The water in the cistern can be changed from time to time if it is found that the air is coming into the curing room too warm.

Whatever form of duct is used, it is necessary to control the entrance of the air into the curing room by means of a damper, because when the wind is strong the air may pass through the duct so rapidly as not to be properly cooled. If it is found that the air is coming in too warm the current should be partly shut off. In factories provided with an engine the air may be blown through the cold-air duct by means of a small blower. The blower could be used at times when the funnel did not work.

From observations which Professor King has made in factories provided with these means of cooling, it appears that with subearth ducts the temperature of the curing rooms may be held at least as much as 7° to 10° F. lower than the temperature of the outside air during the hottest portion of the day.

CONSTRUCTION OF CHEESE-CURING ROOMS.

The efficiency of the methods described above for cooling cheese-curing rooms in summer depends very much upon the thoroughness of the construction of the rooms, by which the outside air is excluded. If anything like the full effectiveness of the subearth duct is to be obtained, two important points must be secured: (1) The walls must be so tight that the pressure and suction of the wind on the building do not drive out the cool air and leave in its place the warm air of the outside, and (2) the walls must be sufficiently poor conductors to permit a relatively small amount of air from the subearth duct to remove all of the heat which penetrates the walls. If the walls permit any air to pass through, then to that extent will the air coming through the duct be decreased. The object sought in the construction of the perfect

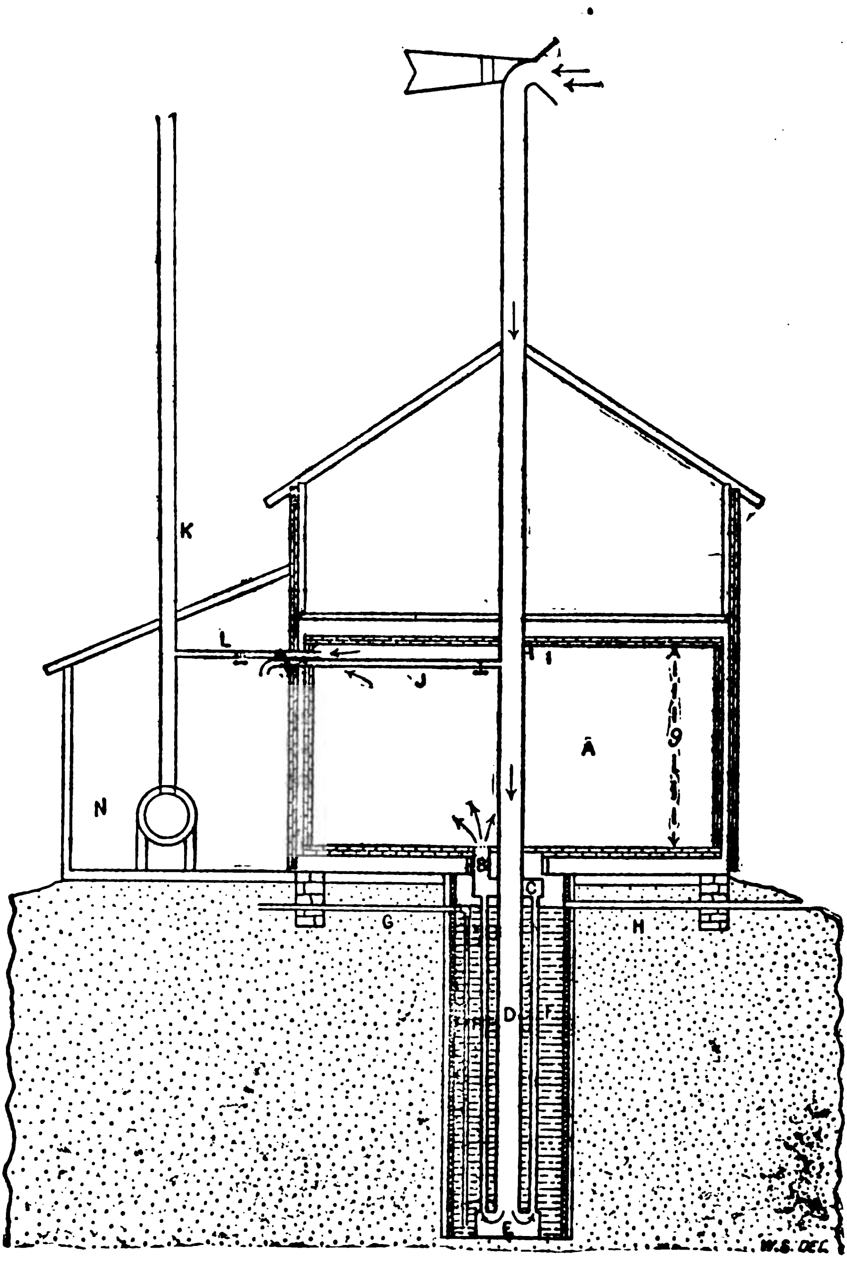


FIG. 4.—Showing method of cooling air with cold water: A, curing room; B, duct leading into curing room; C, E, galvanized iron drums, air and water tight; F, thirteen or more 5-inch flues of galvanized iron, 10 feet long, soldered water-tight to drums to cool air; D, main air duct from funnel; G, water pipe from pump; H, overflow pipe; I, damper in main shaft; J, 4-inch pipe leading from blower to use when there is no wind; K, smoke stack of boiler; L, ventilator from curing room to smoke stack; N, boiler.

curing room is to prevent the entrance of any air except through the subearth duct, or by an opening especially provided to be used only when the air from the duct is too cold or too damp.

In the bulletin of the Wisconsin Station noted above, Professor King gives detailed directions for the proper construction of curing rooms of wood and masonry.

WOODEN ABOVE-GROUND CURING ROOM.

The wooden structure is considered best for a curing room entirely above ground. The room is best located on the north side of the building, away from the direct rays of the sun, and the windows and door should fit closely and be built and closed on the refrigerator plan, if practicable. The walls should be constructed on the principle of cold-storage and icehouse buildings. They should be sheathed on the outside of the studding with matched sheathing and drop siding, with a layer of three-ply acid-proof and waterproof paper between, and on the inside with at least two layers of matched sheathing, with a layer of the three-ply paper between. A still better construction is to leave a dead-air space inside the studding, and to fill in the space between the studding with sawdust or some similar material. The construction is shown in fig. 5. The ceiling and floor should also consist of two thicknesses of matched lumber, with a layer of three-ply acid-proof and waterproof paper between, great care being exercised to make the joints tight at the corners.

UNDERGROUND CURING ROOMS.

Where practicable, underground curing rooms may be built in which the temperature through the hot season can be maintained as low as 58° to 63° if desired. To utilize the ground temperature to best advantage, the curing room should be not less than 9 feet below the level of the ground, and 10 or 12 feet is considered better. The walls are best made of stone up to within 5 feet of the surface, above which a more nonconducting material or construction should be employed. This upper portion may be made of stone, brick, or hollow building tile, laid so as to give an air space. The inside finish should be carried up between the joists, so that when the ceiling is put on no open joints will be left. The floor should be of concrete, since the cooling effect is derived chiefly from the floor. This concrete should be laid with care, and the finishing coat should be smooth and hard so as to give a glossy surface which will be water tight and easy to clean. The ceiling should be made of wood in the same manner as described above for the wooden curing room.

In case the curing room occupies the bank end of the basement of the factory, it will be necessary to build the partition between it and the work room with the same care to exclude heat as if it were an outside wall wholly above ground. If the partition is of wood, the side next to the curing room should have two thicknesses of tongued and grooved flooring with a layer of paper between, and the door should be double and closed and fastened on the refrigerator plan. Windows should also be double and very close fitting, and if light enough can be secured from the north side, windows should only be placed here.

CENTRAL CHEESE-CURING ROOMS.

On account of the expense of constructing suitable curing rooms, with arrangements for holding the temperature within the danger limit, the Wisconsin Station has advocated central cooperative curing rooms or stations in regions where cheese factories are sufficiently thickly located. The cheese from a number of factories would be shipped to these central curing rooms at frequent intervals and ripened under safe and uniform conditions. Where a number of factories are operated under the same management this system would seem to be especially applicable. Aside from the improved quality of the product and the

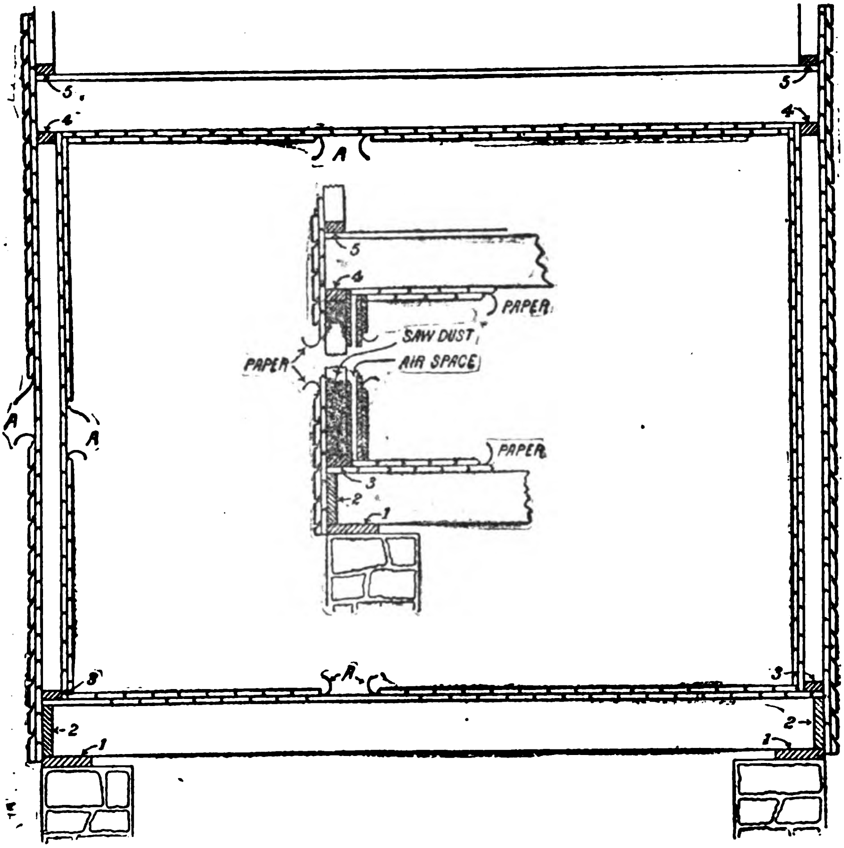


FIG. 5.—Showing the construction of wooden curing room: 1, 1, 1, sill; 2, 2, 2, a 2 by 10 plank spiked to ends of joist; 3, 3, 3, a 2 by 4 scantling spiked down after first layer of floor is laid to toe-nail studs to; 4, 4, 4, a 2 by 4 scantling spiked to upper ends of studding of first story; A, A, A, A, three-ply acid and waterproof paper. The drawing in the center shows space between studding filled with sawdust and another dead-air space to be used when the best ducts can not be provided.

higher price secured, the system would be more economical, being an extension of the cooperative plan, and would permit the employment of experts to cure and care for the cheese. Moreover, it would facilitate the sale of the product, making it possible for buyers to personally inspect large amounts of uniformly cured cheese; would reduce transportation charges, as large shipments could be made, and would enable the cheese makers to hold their product in cold storage without detriment until the conditions were favorable for selling.

IRRIGATION INVESTIGATIONS.

The appropriation act for the U. S. Department of Agriculture for the fiscal year ending June 30, 1899, made provision for the collection "from agricultural colleges, agricultural experiment stations, and other sources, including the employment of practical agents, of valuable information and data on the subject of irrigation, and publishing the same in bulletin form." Congress at its last session increased the appropriation for this work, authorizing the Secretary of Agriculture "to investigate and report upon the laws and institutions relating to irrigation and upon the use of irrigation waters, with special suggestions of better methods for the utilization of irrigation waters in agriculture than those in common use."

The Office of Experiment Stations, to which the work thus provided for was assigned by the Secretary of Agriculture, has, after consultation with experiment station officers and irrigation engineers familiar with the conditions of the irrigated region, undertaken to organize investigations in the following general lines: (1) The collation and publication of information regarding the laws and institutions of the irrigated region in their relation to agriculture, and (2) the publication of available information regarding the use of irrigation waters in agriculture as shown by actual experience of farmers and by experimental investigations. Elwood Mead, formerly State engineer of Wyoming, who has had a long and successful experience as irrigation engineer and administrator of irrigation laws, and is familiar with the agricultural conditions of the arid region, was given immediate direction of the work, with headquarters at Cheyenne, Wyo.

In recognition of the special facilities possessed by the experiment stations for investigations in irrigation as well as of the value of the work already done by some of them, the act of Congress above referred to authorizes and directs these institutions "to cooperate with the Secretary of Agriculture in carrying out said investigations in such manner and to such extent as may be warranted by a due regard to the varying conditions and needs of the respective States and Territories and as may be mutually agreed upon."

In pursuance of the plan of work adopted, the representative of the Department has made a study of the laws and institutions of a portion of the irrigated region, and the results thus far attained have been published in two bulletins.[1] The first of these discusses the laws which control the diversion and use for irrigation of the waters of the Missouri River and its tributaries, embracing the States of Colorado, Kansas, Montana, Nebraska, North Dakota, South Dakota, and Wyoming, and the Northwest Territories of Canada. The second bulletin gives abstracts of the laws for acquiring titles to water in the same region, with the legal forms in use.

No one can read these bulletins without realizing that the farmer from regions of ample rainfall who emigrates to the arid West has many things to learn besides how to build laterals and how and when to spread the water they carry over thirsty fields. The knowledge and skill required to distribute the water is soon acquired, but the working out of social and industrial institutions which will place the rivers, which govern the value of every farm they fertilize, under some form of public control which will secure their just distribution and prevent their becoming the subject of speculation or corporate monopoly is proving in the Western States, as it has in every irrigated land old enough to have a history, to be the enduring and important problem for farmers to solve, and the one on which the reward of their industry and the value of their farms ultimately depend.

The present situation in the States included in the discussion is thus set forth:

> For every acre of irrigated land there has to be a right to water. The title to the latter is of as much importance as the deed to the land. It is much harder to establish. These rights take more forms than the rivers they control, and are acquired by as many methods as there are States to frame laws. In one respect they are alike: No matter whether the user of water derives his title direct from the State, buys it from a ditch company which furnishes water for hire, or from the holder of a speculative claim, it is a source of more perplexity at the outset, and of more hours of anxious thought afterwards, than all the other problems of irrigation combined. This is due in part to the fact that the ownership of streams is new and the nature of property rights therein uncertain; but, whatever the reason, the fact remains that the irrigator whose water right does not furnish grounds for either an inquiry or a grievance is a rare exception. Nor are irrigators alone in finding the limits of a water right hard to define or the problems of stream ownership hard to solve. Lawmakers and courts have both found them equally perplexing.
>
> The reasons for this are not obscure. Because of uncertainty of what these rights should be, or difference of opinion on that question, the irrigation laws of many States have been made so ambiguous and contradictory that the finite intellect is not able to interpret their meaning. As a result there are laws and court decisions to sustain about every view of stream ownership of which the mind of man can conceive, and in some cases they are all found in the statutes and decisions of a single State. * * *
>
> On many rivers there are now a multitude of claims to the common supply. These rights have to be defined in some way. If laws do not define them, then a resort to the courts is all that intervenes between the just claims of water users and anarchy. In many States the exigencies created by a failure to enact an administrative code have compelled the courts to become practically both the creators and enforcers of water laws. They have to devise a procedure for adjudications, supplement the

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[1] U. S. Dept. Agr., Office of Experiment Stations Buls. 58 and 60.

statute law in deciding what rights have been established, and finally have to protect irrigators' priorities by a liberal exercise of government by injunction. The growing volume of this litigation, the uncertain and contradictory character of many of the decisions, is making it a heavy burden to irrigators and a serious menace to progress. Unless it can in some way be restricted, it threatens to impair the value of investments in ditches and the success of this form of agriculture. In ten years the water-right litigation of one State is estimated to have cost over a million dollars. In many sections it has exceeded the money expended in constructing the ditches in which it has its origin. * * *

In considering the problems which these different State laws present, none seem more perplexing, nor in a larger aspect more illogical, than the change which occurs in the control and in the forms of ownership of a river when it crosses a State boundary. * * * So far as the productions or the needs of its farmers are concerned, there is no more reason for half a dozen water laws in the Missouri River watershed than there would be for that many different systems for acquiring titles to land. On the other hand, the complications which would grow out of a half dozen land systems are not to be compared to the complications which are being created by half a dozen different water laws, because these different titles to water and different methods of acquiring them all apply to a common supply.

Perhaps the most useful portion of the bulletins is the explanation of the several State laws and the description of the procedure which farmers have to follow in making and recording water-right filings. No one subject is a source of greater perplexity to the beginner than the establishment of a priority of right in the stream he diverts and nothing has caused greater hardship or loss than failure through lack of knowledge to conform to existing laws. The explanations of State systems are given in detail, so that the bulletins constitute a manual of forms as well as a discussion of principles.

In pursuance of the second line of work determined upon, extensive investigations on the duty of water, as measured by the actual amounts of water used by successful farmers on different soils in growing different crops, are being inaugurated with the cooperation of the experiment stations, irrigation engineers, and practical irrigators in different parts of the arid region. It is believed that these investigations will furnish the information regarding the quantity of water required to irrigate an acre of land, which is a necessity in every irrigated district in the making of water contracts, the planning of works, and the determination and protection of rights in streams, and without which all these important transactions have to be based largely on conjecture.

EXPLANATION OF TERMS.

TERMS USED IN DISCUSSING FERTILIZERS.

Complete fertilizer is one which contains the three essential fertilizing constituents, i. e., nitrogen, phosphoric acid, and potash.

Nitrogen exists in fertilizers in three distinct forms, viz, as organic matter, as ammonia, and as nitrates. It is the most expensive fertilizing ingredient.

Organic nitrogen is nitrogen in combination with other elements either as vegetable or animal matter. The more valuable sources are dried blood, dried meat, tankage, dried fish, and cotton-seed meal.

Ammonia is a compound of nitrogen more readily available to plants than organic nitrogen. The most common form is sulphate of ammonia, or ammonium sulphate. It is one of the first products that results from the decay of vegetable or animal substances.

Nitrates furnish the most readily available forms of nitrogen. The most common are nitrate of soda and nitrate of potash (saltpeter).

Phosphoric acid, one of the essential fertilizing ingredients, is derived from materials called phosphates. It does not exist alone, but in combination, most commonly as phosphate of lime in the form of bones, rock phosphate, and phosphatic slag. Phosphoric acid occurs in fertilizers in three forms—soluble, reverted, and insoluble phosphoric acid.

Potash, as a constituent of fertilizers, exists in a number of forms, but chiefly as chlorid or muriate and as sulphate. All forms are freely soluble in water and are believed to be nearly, if not quite, equally available, but it has been found that the chlorids may injuriously affect the quality of tobacco, potatoes, and certain other crops. The chief sources of potash are the potash salts from Stassfurt, Germany—kainit, sylvinit, muriate of potash, sulphate of soda, and sulphate of potash and magnesia. Wood ashes and cotton-hull ashes are also sources of potash.

TERMS USED IN DISCUSSING FOODS AND FEEDING STUFFS.

Water is contained in all foods and feeding stuffs. The amount varies from 8 to 15 pounds per 100 pounds of such dry materials as hay, straw, or grain to 80 pounds in silage and 90 pounds in some roots.

Dry matter is the portion remaining after removing or excluding the water.

Ash is what is left when the combustible part of a feeding stuff is burned away. It consists chiefly of lime, magnesia, potash, soda, iron, chlorin, and carbonic, sulphuric, and phosphoric acids, and is used largely in making bones. Part of the ash constituents of the food is stored up in the animal's body; the rest is voided in the urine and manure.

Protein (nitrogenous matter) is the name of a group of substances containing nitrogen. Protein furnishes the materials for the lean flesh, blood, skin, muscles, tendons, nerves, hair, horns, wool, casein of milk, albumen of eggs, etc., and is one of the most important constituents of feeding stuffs.

Albuminoids is the name given to one of the most important groups of substances classed together under the general term protein. The albumen of eggs is a type of albuminoids.

Carbohydrates.—The nitrogen-free extract and fiber are often classed together under the name of carbohydrates. The carbohydrates form the largest part of all vegetable foods. They are either stored up as fat or burned in the body to produce heat and energy. The most common and important carbohydrates are sugar and starch.

Fiber, sometimes called crude cellulose, is the framework of plants, and is, as a rule, the most indigestible constituent of feeding stuffs. The coarse fodders, such as hay and straw, contain a much larger proportion of fiber than the grains, oil cakes, etc.

Nitrogen-free extract includes starch, sugar, gums, and the like, and forms an important part of all feeding stuffs, but especially of most grains.

Fat, or the materials dissolved from a feeding stuff by ether, is a substance of mixed character, and may include, besides real fats, wax, the green coloring matter of plants, etc. The fat of food is either stored up in the body as fat or burned, to furnish heat and energy.

MISCELLANEOUS TERMS.

Alkali soils.—Soils found in arid or semiarid regions, which contain an unusual amount of soluble mineral salts (alkali), which effloresce or bloom out on the surface of the soil in the form of a powder or crust in dry weather following rains or irrigation. Two distinct classes of alkali are known: Black alkali, composed largely of carbonate of soda, which is highly corrosive and destructive to vegetation; and white alkali, the characteristic constituent of which is sodium sulphate, and which is much less injurious than black alkali.

Duty of water.—As applied in irrigation this term means the area which a definite volume of a continuous flow of water will irrigate. The duty of a cubic foot per second may be taken as the number of acres of land which a continuous discharge of that volume during the growing season will irrigate.

FARMERS' BULLETINS.

These bulletins are sent free of charge to any address upon application to the Secretary of Agriculture, Washington, D. C. Only the following are available for distribution:

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U. S. DEPARTMENT OF AGRICULTURE.

FARMERS' BULLETIN No. 98.

SUGGESTIONS

TO

SOUTHERN FARMERS.

PREPARED IN THE DIVISION OF PUBLICATIONS.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1899.

LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
DIVISION OF PUBLICATIONS,
Washington, D. C., May 19, 1899.

SIR: I have the honor to submit the following manuscript, prepared under my direction in accordance with your instructions, for publication as Farmers' Bulletin No. 98.

It consists of a summary of papers read at an Interstate Farmers' Convention held at Vicksburg, Miss., February 8–10, 1899. These papers were, in accordance with your proposition to the managers of this convention, supplied to the Department in order that they, or a summary of them covering all the important information they contained, might be published in such a form as would make this information available to the people of the South and the Southwest.

The preparation of this matter for publication having been assigned by your order to this Division, the work was confided to Mr. A. I. Mudd, who has, it is believed, acquitted himself satisfactorily of the somewhat delicate task.

Respectfully,

GEO. WM. HILL, *Chief.*

Hon. JAMES WILSON,
Secretary of Agriculture.

CONTENTS.

Page.

- Introduction ... 5
- Mississippi soils and their capabilities ... 5
  - Divisions of soils ... 5
  - Three classes of soils ... 6
  - Good soil ... 6
  - Lands on which a large amount of fertilizers is used ... 7
  - Beneficial effect of restorative crops ... 7
  - Capabilities of Mississippi soil ... 8
  - Cotton still prevails ... 8
- The dairy cow as a restorer of fertility ... 9
  - Fertilizing constituents absorbed by cotton plant ... 9
  - Feeding value of cotton-seed meal ... 9
  - Constituent elements of a ton of oil meal ... 10
  - Constituent elements of a ton of cotton-seed meal ... 10
  - How to grow cotton, utilize the by-products without reducing income and return all fertilizing constituents to the soil ... 11
  - Experiment in dairying ... 11
  - Productive capacity of the dairy cow ... 12
  - Value of the cotton-seed crop to the South ... 12
- Cotton seed and its products ... 13
  - Cotton, cotton seed, hulls, and cotton-seed meal ... 13
  - Comparative value of cotton seed and corn ... 14
  - Comparative value of cotton-seed meal and cotton seed ... 15
  - Market price of corn, cotton seed, and cotton-seed meal ... 15
  - Quality of beef from cotton-seed products ... 16
  - Cotton-seed products for milk ... 16
  - Cotton-seed meal for horses and mules ... 17
  - Cotton seed and products for hogs and calves ... 17
  - Cotton-seed meal and abortion ... 17
  - Comparative values of corn and cotton-seed crop in Mississippi ... 17
  - Cotton seed and meal as fertilizers ... 17
  - Cotton-seed oil ... 18
- The relation of live-stock farming to home-making ... 19
  - Pure breeds only are deserving of attention ... 19
  - Value of influence of pure-bred stock upon the intellectual life of the family ... 19
  - Intellectual vigor in the farm home ... 20
- Southern agriculture, Mississippi and Louisiana ... 20
  - Production of soil areas ... 20
  - Productiveness of the Mississippi Valley ... 21
  - Great variety of productive soils ... 22
  - The finest cotton in the world ... 23
  - Timber of all kinds ... 23
  - Too much land, too many mules, and too much ignorant labor ... 24

Page.

Expansion in the farmer and the farmer in expansion........................ 25
  Agricultural schools 25
  Scientific farming 25
  Prospective shortage in wheat supply of the world........................ 26
  Higher education for the farmer and mechanic 27
  Agricultural publications issued by the Government........................ 27
Horticulture.. 28
  Fruits and overstocking.. 28
    Apples.. 28
    Pears.. 29
    Peaches 29
    Apricots.. 29
    Plums 30
    Cherries 30
    Strawberries.. 31
  Bamboo 31
Agricultural education.. 32
  Endowment of agricultural colleges 32
  Modern idea of practical farm education.. 32
  Methods of teaching 34
  The school must keep in close touch with the farmer........................ 34
  To check the tendency cityward 35
Stocks and how to feed them 35
  Losing money growing cotton.. 35
  Mississippi and Iowa production compared 36
  Mixed husbandry and diversified agriculture 37
  Rotation of crops.. 37
  What was raised at the Louisiana Experiment Station........................ 38
  Growing live stock.. 39
  Crops at the college farm.. 39
  Varieties of hay can be grown 40
The peculiar advantages of the South for growing forage crops and feeding stock 40
  Possibility of raising high-grade animals in the South 40
  Raising cattle for beef or dairy purposes.. 41
  Advantages for economical and profitable feeding........................ 41
  Protein concentrates 42
  Cotton seed 42
  Forage crops.. 43
  Pasturing facilities.. 44
  Overproduction.. 44
  Market for Southern stock 45
The Weather Bureau and the farmer.. 45
  Rain forecasts 45
  Cold-wave warnings 45
  River and flood warnings.. 46
  Storm warnings 46
  Extension of meteorological service 46
  Student assistants 47
  How weather forecasts are made.. 47

SUGGESTIONS TO SOUTHERN FARMERS.

INTRODUCTION.

At an Interstate Farmers' Convention held at Vicksburg, Miss., February 8–10, 1899, many prominent and representative men were present, including the Hon. James Wilson, Secretary of Agriculture; Governor Shaw, of Iowa, and ex-Governor Hoard, of Wisconsin.

Addresses of welcome were delivered by Hon. W. L. Trowbridge, mayor of Vicksburg; Hon. S. S. Hudson, on behalf of the board of trade, and Hon. John A. Redhead, on behalf of the agricultural interests of Mississippi, to which suitable responses were made by the first three gentlemen mentioned.

From the other addresses presented at this convention, which were placed in the hands of the Secretary of Agriculture, the following summaries have been prepared by his direction. The necessity of condensation forbade the publication of all these papers in full, and thus necessarily much of the eloquence and grace of diction which characterized these addresses has unfortunately been lost; but an earnest effort has been made to preserve of each one all the practical information the speaker sought to convey. Owing to the fact that no arrangements had been made for reporting the proceedings in full, it has been impossible to reproduce any part of the discussions to which the several papers gave rise.

MISSISSIPPI SOILS AND THEIR CAPABILITIES.

DIVISIONS OF SOILS.

Prof. W. L. Hutchinson, director of the Mississippi Experiment Station, first called attention to a colored map which he said showed the divisions of the soils of Mississippi essentially as made by Dr. Hilgard, former State geologist. The divisions are as follows:

(1) Northeastern prairie region: (a) black yellow prairie, (b) Pontotoc ridge; (2) flat-woods region; (3) brown and yellow loam region; (4) sandy-loam oak uplands region; (5) cane hills region; (6) alluvial or delta region; (7) sandy-loam and central prairie region; (8) pine-woods sandy region.

He then said that the soils of the Northeastern Prairie region are calcareous clays. Part of the soils are black and part are known as yellow or post-oak prairie. In the western part of this region the land is rolling and the soils of the hills, as a rule, are yellow clays, while the valleys are sandy loams formed by washings from the hills. The soils of the flat woods are somewhat variable, but are mainly heavy clays. The surface is level and therefore the drainage is not good.

The yellow and brown loam region is characterized by soils with a very large amount of fine material or silt of a brown or yellow color lying like a blanket on orange colored sand or gravel, which underlies all of this region. The Yazoo delta is alluvial, or made, land formed by the overflow of the great river or its tributaries. The oak uplands have a sandy or loamy soil with a yellow clay subsoil, and the same is true of the soils of the pine-woods region, though here both surface and subsoil have more sand. The soils of the cane hills are formed of calcareous silt.

THREE CLASSES OF SOILS.

A better practical idea of the soils of the State may be arrived at by dividing the soils into three classes, viz: (1) Those having good water conditions and rich in plant food; (2) those rich in plant food, but with unsatisfactory water conditions, and (3) those with good water conditions but deficient in plant food, and hence require the constant use of fertilizers. These three classes comprise about all the soils in the State, though there may be small areas deficient in plant food and with poor water conditions.

GOOD SOIL.

The speaker said that his audience would appreciate the fact that practical farmers differ very much as to what constitutes a good soil. Many farmers agree with the German's idea, that it is a place to put fertilizers, while others, raised differently, have little patience with land that requires fertilization. The truth is, give a farmer good water conditions, do not let his crops suffer from either drought or excessive rains, and farming is made simple, safe, and easy, even if he does have to fertilize.

The farmer who owns land that takes the seasons as they come and furnishes his crop with a good and suitable supply of water at all times, and whose land is rich in plant food so as not to require the use of fertilizers owns what is known as fertile land. He has a treasure and should be slow to part with it. In every section of the State there are some such soils, and the main bodies of such lands will be found on the well-drained farms in the Delta and in the well-drained valleys and bottoms in whatever section they may occur.

There is a second class lying side by side with the first, and large areas of it are found in Mississippi. They are rich in plant food, but the water conditions are not good, or they are still in forest. They are valuable, too, but only in proportion to the expense and effort necessary to make them like the first. As a rule their owners do not know their value. They are in the northeastern prairie region, in the brown loam region, in every valley and "bottom" in this State, and in many a so-called "old field." To put them in good shape, frequently nothing is required but a crop of melilotus, cowpeas, or a few crops of lespedeza; and in the valleys and bottoms a few good ditches with an occasional tile drain.

LANDS ON WHICH A LARGE AMOUNT OF FERTILIZERS IS USED.

A section that uses a large amount of fertilizers is usually a prosperous one. The lands have a loam texture, the water conditions are good, and many persons already class such soils as the best. It may be that the time is not far distant when we will all agree with them. Such lands respond promptly and liberally to every well-directed effort. They are easy to till and are safe soils. You can buy them in Mississippi for a song. They are in the pine-woods region and in the oak uplands region. This is the future trucking section of the State, and whenever proper shipping facilities are provided this may become the most valuable section, as truck farming is one of the most profitable branches of agriculture. The plant food in these soils is comparatively small, but the water conditions are good, and for almost any purpose the necessary fertilization is easy. Precisely similar lands along the Atlantic seaboard sell at from $50 to $200 per acre.

For an equal area, probably no other State has more rich soil, and certainly none more good soil, than Mississippi.

Fifty dollars per acre is about the highest market value ever reached by the best lands in the State. This was about forty years ago; and as very little of this value was represented by improvements, the price would indicate a very high degree of productiveness in the soils. Where now, you ask, are these once high-priced lands? When you look on the "old fields" of the State, you see what were once the best lands within her borders. The plant food in them could not possibly have been exhausted in so short a time. Except where they have been damaged by excessive washings or erosion, they are still valuable, and many of them will yet be made to give larger yields than they did in the palmy days of yore. Some of them have been so badly washed and gullied that they are of very little if any value, and are likely to remain so for generations to come.

The clean culture necessary in cotton farming has the effect of rapidly exhausting the humus or organic matter in soils, and for this reason many of the soils are deficient in this very important material. This must be restored as promptly as possible, and by the best means available.

BENEFICIAL EFFECTS OF RESTORATIVE CROPS.

The professor said he would especially call attention to the very marked beneficial effects of restorative crops on worn-out soils. In the prairie section a crop of melilotus has increased the yield of badly worn soil at least fourfold, the yield being a bale of cotton per acre. There are larger areas of these lands, not so badly worn, where the yield may be doubled by similar treatment. Cowpeas are just as good for this purpose, and they grow well on all kinds of soil in the State. The lands in the different sections are not equally well adapted to all classes of crops or to different kinds of farming. Naturally, they maintain different amounts of water, and this makes one class better adapted to early truck farming and another class to the growing of grasses and forage. Too much stress can not be laid upon the fact that the esteem in which lands in the State have been held has been almost wholly based on their adaptability to growing cotton. Trucking is in its infancy and is practiced in only a few sections, and these may not by any means be the best for this purpose. The values attached to lands by farmers in the State are never based on their adaptability to growing grasses and forage crops.

"In the whole State," the speaker said, "I doubt if there is as much as one township of good land in good condition that is in good pasture grass. We absolutely have no idea of the adaptability of any of our soils to the production of the different grades of tobacco, and yet there is much to indicate that Mississippi has some very fine tobacco soils."

CAPABILITIES OF MISSISSIPPI SOIL.

In regard to the capabilities of the soil of Mississippi and what a Mississippi farmer may do for himself, the speaker said that on every farm in the State the farmer may not only make a good living for himself and family, but can live luxuriously.

There is not a timothy meadow or blue-grass pasture in the State, but with bermuda, lespedeza, carpet grass, alsike clover, red top, turf oats, and hairy vetch good pastures can be made which will furnish grazing equal to any in this country. Red clover can be grown in the northeastern prairie region and in the brown loam region, and cowpeas and lespedeza can be grown in every section of the State. There are probably as good alfalfa soils as may be found anywhere, but the actual demonstration is yet to be made. On the well-drained alluvial lands at the sugar-experiment station in Louisiana Professor Stubbs has grown from 10 to 12 tons per acre. Where properly drained there is no reason why the soils in the Delta region of Mississippi would not do as well. It is grown satisfactorily in the valleys of the northeastern prairie region.

Fifty bushels of corn per acre can be grown in the State.

COTTON STILL PREVAILS.

In conclusion, the speaker said:

> We have fine cotton lands, and cotton grows well in all sections except near the coast. I have great respect for cotton. Conventions meet for the purpose of lessening its area; speakers condemn it as unprofitable and ruinous; farmers' institutes

assemble to give it a black eye, but still we see it prevail and we hear the darkey singing in the cotton patch and we see the millions still clothed in it. I have an idea this will continue; but cheap cotton undoubtedly means cheap labor. The man who labors, and wants good wages for it, must needs do something other than produce 4½-cent cotton.

Can a farmer make money on Mississippi soils? If he is industrious, if he studies his business and keeps abreast with the times, if he uses the best business methods, and if he produces the best of whatever he markets, he may hope to gain a competency, not a fortune.

THE DAIRY COW AS A RESTORER OF FERTILITY.

FERTILIZING CONSTITUENTS ABSORBED BY COTTON PLANT.

Prof. T. L. Haecker, of the University of Minnesota, prefaced his remarks with the statement that he had had little opportunity to investigate the conditions obtaining in the cotton belt. He said that the people of that section were probably undergoing an experience which sooner or later comes to every section of our land. Wheat was grown almost exclusively in the North until the soil refused to respond. No one seemed to know why, but when wheat failed they began to depend more upon live stock. As the live stock increased the land brought better crops, and it gradually dawned upon them that the failure of crops was due to lack of fertility, and that by diversified farming they could restore it and secure as good, if not better, returns than they received from the virgin soil.

It is likely that the soil of the cotton belt has been impoverished by constant cropping and inadequate fertilizing. The cotton crop makes heavy drafts upon the soil and if it is not heavily fertilized in return it will become exhausted. The commercial value of the fertilizing constituents absorbed by the cotton plant amounts to $3.83 per acre, aggregating a little over $47,000,000 worth per year. Every dollar's worth of this fertility that has not been returned to the soil is a bonded indebtedness which will exact exorbitant interest by way of reduced crops until that which rightfully belongs to the soil has been returned. The report of the Secretary of Agriculture for the year 1897 shows that during that year 623,386,638 pounds of cotton-seed meal, valued at $5,515,800, were exported from this country to Europe. The fertilizing value alone of this product, at the lowest commercial values, amounts to $6,325,600.

FEEDING VALUE OF COTTON-SEED MEAL.

At the present prices of grains and mill stuffs its feeding value amounts to $9,226,122, making the actual value of the exported cotton-seed meal $15,551,726. All of this is sold to the European dairymen and meat growers for five and one-half million dollars. This meal is converted into products which come in competition with our products in foreign markets.

As to the accuracy of the feeding value placed upon cotton-seed meal there may be some doubt, but to demonstrate its money value as feeding stuff let us examine the subject from the standpoint of the Northwestern dairyman. Only a half dozen years ago bran was a drug on the market, and it was in many cases used as fuel to operate the flouring mills. Now, even in sections where wheat raising is the leading crop but where creameries have been established, not only is all the bran made at the local mills engaged by the farmers weeks in advance, but from thirty to forty car loads are shipped back from the great milling centers into each of the country stations and sold to the farmers for milk and meat production. Does it not seem strange that the farmer should buy and pay cash for mill products when his granaries and bins are loaded with oats, barley, corn, and rye, and when he has more roughness in the shape of hay, straw, corn fodder, and stover than he can use? He pays $10 for a ton of bran. It contains 238 pounds of water. He is certainly not buying the water. It contains 116 pounds of ash, 58 pounds of indigestible protein, 1,258 pounds of carbohydrates, and 80 pounds of fat. It would be absurd for the farmer to pay $10 per ton for these substances when he has more of them at home than he has use for. The only substance in the ton of bran not enumerated above is 250 pounds of digestible protein, and the logical conclusion is that the farmer pays for the 250 pounds of protein.

CONSTITUENT ELEMENTS OF A TON OF OIL MEAL.

A ton of oil meal contains 184 pounds of water, 114 pounds of ash, 72 pounds of indigestible protein, 886 pounds of carbohydrates, and 158 pounds of ether extract, or fat. Surely no sane person would be guilty of buying these substances at the rate of $22 per ton when his farm is already overstocked. As the digestible protein is the only nutrient he lacks, it must be that which he buys. Now, that ton of linseed meal contains 586 pounds of digestible protein. Since the cost of nutrient in bran is 4 cents a pound, the intelligent farmer sees no objection to buying the oil meal at $22 per ton.

CONSTITUENT ELEMENTS OF A TON OF COTTON-SEED MEAL.

A ton of cotton-seed meal contains 164 pounds of water, 144 pounds of ash, 106 pounds of indigestible protein, 584 pounds of carbohydrates, and 262 pounds of fat. As stated before, when the farmer has more of these substances at home than he can use, he therefore buys the digestible protein. Since he can get it in more condensed form and with it less alloy when he buys cotton-seed meal, he finds no objection to paying at the rate of 4 cents per pound for the 740 pounds of digestible protein in a ton of cotton-seed meal, which fixes its commercial value as a feed stuff at $29.60. In the 623,386,638 pounds of cotton-seed meal exported in 1897 there were 230,653,056 pounds of digestible protein, which at 4 cents per pound amounts to $9,226,122. So, if farmers can buy digestible protein at the rate of 4 cents per pound in bran and oil meal and make it return them 7.53 cents per pound by converting it into dairy products, the estimated commercial value of the exported cotton-seed meal is a very conservative one. The South can not afford to export its cotton-seed meal at any such figure.

The annual cotton-seed crop is estimated at 4,500,000 tons. A ton of cotton seed contains 250 pounds of digestible protein, making a ton of cotton seed and a ton of bran of equal feeding value. With bran at $10 a ton, the feeding value of the 4,500,000 tons of cotton seed would be $45,000,000. Valuing nitrogen at 14 cents, phosphoric acid at 5 cents, and potash at 4 cents, the manurial value of the cotton-seed crop is $49,365,000, making its total annual value $94,365,000.

HOW TO GROW COTTON, UTILIZE THE BY-PRODUCTS WITHOUT REDUCING INCOME, AND RETURN ALL FERTILIZING CONSTITUENTS TO THE SOIL.

The cotton crop of Mississippi covers an area of about two and one-half million acres from which is removed $9,575,000 worth of fertilizing constituents annually. The problem to be solved is: How to continue cotton growing, utilize the by-products on the plantation without reducing the income therefrom, and at the same time return all the fertilizing constituents to the soil? In order to accomplish this, the product must be a staple article that has ready sale, it must uniformly bring a good margin, must be in condensed form so that freight rates will be light, and must not contain any fertilizing constituents.

The speaker said:

> I know of only one animal that can fill these requirements, and that is the dairy-bred cow, and the product butter. Butter fat contains no nitrogen. Therefore if the by-products of the cotton plant are fed to cows that do not convert feed into meat, but into milk, all the fertilizing constituents will be found in the skim milk and in the excreta, and if these are retained on the farm and only the butter marketed, nothing will leave the farm that has any value as a fertilizer, and the net return to the cow owner will be 7½ cents in cash for every 4 cents worth of protein consumed.

EXPERIMENT IN DAIRYING.

He then said that on such an occasion opinions are out of place. Therefore he would show the results of an actual and careful experiment covering a period of four months of stall feeding, from January 1 to May 1, when all feed was carefully weighed out to each cow in the college herd, all milkings weighed and tested for butter fat, and analyses made of all food stuffs used.

There were 22 cows in the herd. The digestible protein eaten amounted to 7,150.12 pounds; yield of butter fat, 2,636.71 pounds; and yield of butter 3,076.19 pounds.

The herd consumed on an average 2.42 pounds of digestible protein for each pound of butter yielded, and returned 7.53 cents for every 4 cents worth of protein consumed after deducting cost of manufacture, transportation, and commission. The cost of the protein was much less than 4 cents, and the butter was sold for more than the amount shown in these calculations, but the figures used are applicable to present conditions and are what may be generally expected as ruling prices under good management. The returns made for food consumed are below what might be realized if a whole winter's work is taken into account. The results given are for the last three months of a seven months' stall-feeding. The cows came in in the latter part of summer and in early fall and had been in milk from three to four months, when the record quoted began. When such results can be obtained in a climate where seven months of stall-feeding is required, as good, if not better, results should be secured in a State where only three months of stall-feeding is necessary.

PRODUCTIVE CAPACITY OF THE DAIRY COW.

The wonderfully productive capacity of a dairy cow is further illustrated by the record of the college herd for two consecutive years. It is a mixed herd composed of representatives of the various dairy breeds and their grades, and grade shorthorns, representing the average cow as found on Minnesota farms. The results obtained are such as may be expected of a fairly well selected herd under good care, but the yield as a herd is better than could be secured from an ordinary herd of common cows.

The cost for feed during the year 1895 at local market prices averaged $28.47 per cow. The average yield of milk per cow was 7,418 pounds, or 872 gallons, and the average yield of butter was 353 pounds. The cost of feed to produce a pound of butter was 8 cents. Valuing the butter at 15 cents a pound and skim milk at 15 cents per hundred pounds makes the gross return $62.68. Deducting $28.47, the cost of the feed, we have a net return of $34.21 per cow.

In 1896 the cost for feed was $22.12; the average yield of milk was 7,454 pounds, or 877 gallons, per cow; the average yield of butter was 349 pounds, and the cost of feed to produce a pound of butter was 6⅓ cents. The gross return was $62.18 and the net return $40.06 per cow.

It is not in the cotton nor in the oil extracted from the seed that the fertility is lost, but it is in the parting with the cotton-seed cake or meal that the loss occurs. If you feed the cake and meal to dairy cows all the fertility will remain on the plantation and your cash receipts will be twice as large as would be the case if this by-product was sold.

VALUE OF THE COTTON-SEED CROP TO THE SOUTH.

The speaker summarized the value of the cotton-seed crop as follows:

> I have shown that the annual manurial value of the cotton seed is $49,365,000 and the market value $45,000,000. If converted into butter, it would bring in a net return of $78,750,000. Add to this its manurial value, which you would keep, and we have as the actual value of the cotton-seed crop to the South the fabulous sum of $128,115,000.
>
> To save annually this enormous revenue is a very simple proposition. Go into dairying with the dairy cow.

COTTON SEED AND ITS PRODUCTS.

COTTON, COTTON SEED, HULLS, AND COTTON-SEED MEAL.

Prof. B. W. Kilgore, State chemist and professor of chemistry, Agricultural College, Mississippi, pointed out the great value of cotton seed and its products for feed and other purposes.

He said that Mississippi produced about 1,600,000 bales of cotton during each of the past two years. Cotton as it is picked yields a little less than one-third lint and a little more than two-thirds seed. A cotton crop of 1,600,000 bales, therefore, gives about 800,000 tons of seed, which is 320,000 tons, or 40 per cent short of a 40,000,000 bushel corn crop for the State.

One ton (2,000 pounds) of cotton seed, when treated at an oil mill, yields about 725 pounds meal, 1,000 pounds hulls, linters, etc., and 275 pounds of oil—37 gallons.

Cotton-seed hulls are used as fuel in the engines of oil mills, and very largely as food for cattle. They are worth from one-half to two-thirds as much as grass hay and are an excellent and handy diluent with which to feed cotton-seed meal. Hundreds of thousands of cattle and large numbers of sheep are each winter fattened on hulls and meal at and in the vicinity of the oil mills of the South. Milk cows are also fed on rations made up largely of hulls and meal. The rations fed to fattening cattle are 3 to 4 pounds at first, which are gradually increased to 6, 8, and even 10 pounds per head each day and all the hulls the animals will eat. The proportions have varied from 2 to 6 pounds of hulls to 1 pound of meal, the best results having been obtained on 3 to 4 pounds of hulls to 1 of meal. For long feeding periods and rapid gains this is a most excellent ration.

Numerous experiments have shown that cotton-seed meal produces in the same rations more and cheaper beef than the same amount of corn meal, and generally more than wheat bran, linseed meal, and the other concentrated feeds. Cotton-seed meal stands at the head of concentrated feeds. This is a sweeping statement, but the experiments are numerous, and the evidence upon which it is based is abundant.

In four years' experiments at the Pennsylvania Experiment Station, mixtures of corn meal and cotton seed with coarse foods produced better and cheaper gains than corn meal alone with the same coarse foods, cotton-seed meal replacing more than its own weight of corn meal in the rations and producing the amount of food required to produce a pound of gain.

At the Texas station, in three years' experiments in fattening 160 Texas steers and 8 cows on cotton-seed products on different rations, in comparison with each other and with corn, the obtained results in all cases indicated the superior feeding qualities of cotton-seed products over corn. From these experiments (and a large number of others might be given) it is seen that cotton-seed meal is a better beef producer than corn[1]—that a given weight of cotton-seed meal will make more beef than will an equal weight of corn or corn meal. Of the large number of feeding experiments with cotton-seed meal but few are adapted to determining accurately just how much corn meal a pound of cotton-seed meal is equal to.

The experiments at the Pennsylvania station, eight in number, and an experiment now well advanced at the Mississippi station, the result of which the director has permitted the use of with the understanding that it only indicates what the final result will be, are the only ones found suited to the purpose in view.

These nine experiments show that 1 pound of cotton-seed meal has produced in the same rations as much beef as 1.34 pounds to 2 pounds of corn meal, the average being 1 pound of cotton seed to 1.73 pounds of corn meal.

Though it can not be said that this ratio is absolutely correct, or that results corresponding to this ratio will in all cases be gotten with these two foods, yet when fed in the best way in combination with other feeds results reasonably close to it may be expected.

This ratio—1 pound of cotton-seed meal equal in beef-producing value to 1.73 pounds of corn meal—has a significant meaning in Mississippi. Corn and cotton-seed meal have close to the same selling price in her markets.

COMPARATIVE VALUE OF COTTON SEED AND CORN.

The cotton seed is not understood in its home, the South, as it should be, nor is its feeding value fully appreciated. Cotton seed is not so readily eaten as its products, especially meal. Nevertheless, we know it to be a valuable food, and many experiments show that, pound for pound, cotton seed is fully equal in feeding value to corn. Experiments with cotton seed and corn, as with cotton-seed meal and corn meal, have not been generally of such a nature as to enable us to arrive at the exact comparative value of these two materials.

At the Texas station, cotton seed in rations produced cheaper and more rapid gains for short periods than either corn or cotton-seed meal. In long periods the seed loaded the animals with fat so quickly that the rate of laying on flesh was greatly decreased. Raw and boiled seed at $7 per ton made cheaper but smaller gains than cotton-seed meal at $20 per ton. Rations with corn were the dearest ones fed. Two experiments at the Texas station show that 1 pound of cotton seed equals in beef-producing value 1.21 pounds of corn. An incomplete experiment at the Mississippi station shows that 1 pound of cotton seed is equal to 1.06 pounds of corn-and-cob meal. Averaging this and the Texas results give 1 pound of cotton seed equal to 1.13 pounds of corn meal.

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[1] The Cotton Plant, Bulletin No. 33, Office of Experiment Stations, p. 385.

COMPARATIVE FEEDING VALUE OF COTTON-SEED MEAL AND COTTON SEED.

Many experiments have shown that cotton-seed meal produces pound for pound more beef than cotton seed, but only a limited number of these experiments are of such a kind as to give anything like a definite idea of the relative beef-producing powers of the two. Two experiments at the Texas station, already referred to, and one now in progress at the Mississippi station show one pound of cotton-seed meal to have produced as much beef as 1.54, 1.36, and 1.50 pounds of cotton seed, respectively.

This shows as an average of the three experiments that 1 pound of cotton-seed meal has made as much beef as 1.47 pounds of cotton seed. While it is not contended that this represents the exact relative feeding value of these materials, it is believed that their values as feeds do not differ widely from the relation represented by these figures, 1:1.47.

MARKET PRICE OF CORN, COTTON SEED, AND COTTON-SEED MEAL.

The market prices of cotton seed, cotton-seed meal, and corn are about as follows:

	Per ton.
Cotton seed, 10 cents per bushel, equal to 30 cents per 100 pounds, equal to	$6.00
Cotton-seed meal, 80 cents per 100 pounds, equal to	16.00
Corn, 40 cents per bushel, equal to 71 cents per 100 pounds, equal to	14.20

Combining the comparative feeding values and selling prices of corn, cotton seed, and cotton-seed meal, the following relations are shown to exist:

First. One pound of cotton-seed meal equals 1.73 pounds of corn meal.

(*a*) When corn is worth 40 cents per bushel, equal to 17 cents per 100 pounds, cotton-seed meal should be worth $1.23 per 100 pounds, equal to $24.60 per ton.

(*b*) When cotton-seed meal is worth 80 cents per 100 pounds, equal to $16 per ton, corn should be worth 46 cents per 100 pounds, equal to 25.8 cents per bushel.

Second. One pound of cotton seed equals 1.13 pounds of corn meal.

(*a*) When corn is worth 40 cents per bushel, equal to 71 cents per 100 pounds, cotton seed should be worth 80 cents per 100 pounds, equal to 26.6 cents per bushel and $16 per ton.

(b) When cotton seed is worth 10 cents per bushel, equal to 30 cents per 100 pounds, corn should be worth 26.6 per 100 pounds, equal to 14.9 cents per bushel.

Third. One pound of cotton-seed meal equals 1.47 pounds of cotton seed.

(a) When cotton seed is worth 10 cents per bushel, equal to 30 cents per 100 pounds, or $6 per ton, cotton-seed meal should be worth 44 cents per 100 pounds, or $8.60 per ton.

(b) When cotton-seed meal is worth 80 cents per 100 pounds, equal to $16 per ton, cotton seed should be worth 55 cents per 100 pounds, equal to 18.3 cents per bushel, or $11 per ton.

These statements, though they are statements, as I believe, of facts, may be somewhat of a surprise to many of you. They are rather concentrated, but not more so than the feeds with which we are dealing. It may be difficult for you to accept them and digest them, yet the animals have digested the feeds and given us the facts and we can not question the findings except through the medium of other animals in other experiments. This method of recourse is open to everyone, and the oftener the statements are questioned and answered in this way, the better will it be for the real truth and the knowledge of these most valuable feeding materials.

QUALITY OF BEEF FROM COTTON-SEED PRODUCTS.

Cotton-seed products beef is good. Despite the occasional statements in the agricultural press that beef produced from cotton-seed products is of poor quality, an examination of all experiments on the subject failed to disclose evidence to justify the statement. It is true that the fat of animals fed on cotton-seed products has a melting point of two to six degrees higher—the fat harder and firmer—than that of animals fattened on corn; but this has not, so far as known, caused any objection to be made against the eating qualities of the beef.

COTTON-SEED PRODUCTS FOR MILK.

Cotton seed and its products are valuable milk and butter producers. They do not injure the milk for drinking purposes, but when fed in too large quantity they give butter a higher melting point and make it quite firm. This is an advantage in a warm summer climate, but at the same time the texture is injured, the butter being sticky and the flavor poor. When, however, seed and meal are properly combined with grain and hay foods this injurious effect on the quality of the butter is not apparent. Three to four pounds of cotton seed or meal may be fed to a cow each day without materially affecting the butter. Cotton-seed meal is valuable as a dairy food, and for mixing with cotton-seed hulls, corn fodder, and the grass hays it has no superior. Numerous experiments have shown cotton-seed meal in the same rations to produce pound for pound more milk and butter than corn meal, wheat bran, or the other grains and concentrated feeds in use. The experiments which have been made for milk production, although made with the view of determining the effect on the health of the animal and the quality and quantity of milk and butter produced, justify the same general statements in regard to milk and butter production that have been made about cotton seed and cotton-seed meal in their relations to each other, and to corn for beef production.

The Mississippi station has for two winters been working on the relative milk and butter producing powers of cotton seed, cotton-seed meal, and corn. The director has allowed the statement to be made in advance of publication that the results indicate that these feeds have about the same relative milk and butter producing values as has already been stated for them for beef production.

COTTON-SEED MEAL FOR HORSES AND MULES.

Cotton-seed meal has been fed to horses and mules to a limited extent, but there is not much definite information at hand as to the results. In three cases 2 pounds of cotton-seed meal have been fed daily in connection with other grain feeds and hays with good results.

COTTON SEED AND PRODUCTS FOR HOGS AND CALVES.

Nearly all carefully conducted experiments show that neither cotton seed nor meal can be fed profitably to hogs and young calves. They are injurious to these animals, and death frequently results when such feeding is continued. Whether death is due to loose lint, large amount of oil, hard and sharp seed coats, or whether cotton-seed products contain a toxic principle, or whether such is developed as the result of decomposition outside or change within the animal body, is yet an open question, and is an important one, too, to be solved in connection with the problem of feeding cotton-seed products.

COTTON-SEED MEAL AND ABORTION.

It seems to be the well-founded opinion of veterinarians, dairymen, and feeders that cotton-seed meal does not produce abortion. That like similar feeds it can be fed so as to produce abortion, but it is safe and free from producing such results when rationally fed.

PARATIVE VALUES OF CORN AND COTTON-SEED CROPS IN MISSISSIPPI.

In 1897 the estimated corn crop of Mississippi was 30,000,000 bushels, equal to 840,000 tons of grain. The cotton crop for the same year was 1,600,000 bales, which would produce about 800,000 tons of cotton seed. This is 40,000 tons, or 5 per cent less cotton seed than corn.

The corn crop of 1898 was estimated at 40,000,000 bushels, or 1,120,000 tons, of grain. The cotton crop was 1,600,000 bales, and 800,000 tons of seed. The cotton-seed crop was 40 per cent short in weight of the corn crop, but, compared on the basis of the feeding value previously stated, it was but 24 per cent less in feeding value than Mississippi's large corn crop. We do not get correspondingly as much out of the cotton-seed crop as we do out of the corn crop. We are lacking in knowledge as to how to feed the seed and its products to the best advantage, and also in stock to feed. We are growing the seed, and can grow the stock.

COTTON SEED AND MEAL AS FERTILIZERS.

The largest part of the nitrogen in the fertilizers sold in Mississippi, about three-fourths, is derived from cotton-seed meal. It is our great and cheap source of nitrogen.

One ton (2,000 pounds) of cotton seed contains:

Nitrogen, 62 pounds, at 12½ cents	$7.75
Phosphoric acid, 26 pounds, at 4½ cents	1.17
Potash, 24 pounds, at 5 cents	1.20
Fertilizing value of a ton of cotton seed	10.12

One ton (2,000 pounds) cotton-seed meal contains:

Nitrogen, 136 pounds, at 12½ cents	$17.00
Phosphoric acid, 56 pounds, at 4½ cents	2.52
Potash, 36 pounds, at 5 cents	1.80
Fertilizing value of a ton of cotton-seed meal	21.32

It requires about 2¾ tons of seed to yield a ton of meal, and a ton of meal contains more than double the quantity of fertilizing materials contained in a ton of seed.

On the same basis, 1 ton (2,000 pounds) of corn has:

Nitrogen, 32 pounds, at 12½ cents	$4.00
Phosphoric acid, 13 pounds, at 4½ cents	.58
Potash, 8 pounds, at 5 cents	.40
Fertilizing value of 1 ton of corn	4.98

This shows that a ton of corn or corn meal contains less than one-half as much valuable fertilizing materials as cotton seed and less than one-fourth as much as is contained in cotton-seed meal.

COTTON-SEED OIL.

Cotton-seed oil is obtained by separating the seed coats or hulls from the kernels of the seed and expressing the oil from these. About 26 per cent of the seed of the State of Mississippi goes to the oil mills. A ton of seed yields about 275 pounds, or 37 gallons, of crude oil.

Crude cotton-seed oil is worth about 18 cents per gallon, or 2.3 cents per pound; refined yellow oils 25 cents per gallon, or 3.3 cents per pound, and the white oils 30 cents per gallon, or 4 cents per pound. Refined cotton-seed oil is used for making compound lard, cottolene, and lard substitutes for cooking purposes, and oleomargarine, butterine, and butter substitutes. It has been estimated by experts that 90 per cent of the olive oil sold in this country is cotton-seed oil. Cotton-seed oil sells for from 3 to 4 cents per pound; when called olive oil it is worth 7 cents; under the name of compound lard it sells for from 5 to 6 cents, and when called butter its value goes up to 15 cents per pound.

It is a pure, wholesome, and nutritious oil—a legitimate and necessary constituent in human food, and might with much saving and advantage be substituted for the lard and bacon brought from a distance and consumed in the vicinity of the oil mills.

The estimation in which it is held in foreign countries is shown by the fact that the exportation of cotton-seed oil and its compounds between 1884 and 1893 increased 162 per cent, while the exportation of lard increased only 37 per cent.

THE RELATION OF LIVE-STOCK FARMING TO HOME MAKING.

PURE BREEDS ONLY ARE DESERVING OF ATTENTION.

The following extracts are from the address of Mrs. Virginia C. Meredith, of the University of Minnesota:

By the advanced farmer of to-day it is clearly recognized that the pure breeds of stock only are deserving of his attention—that no other class merits the devotion of his mental and material efforts. It is true that in extensive farming the foundation of herd or flock may be, and generally is, far from being eligible to registry; yet even there the successive sires are usually pure bred; thus the flock and herd grow practically toward purity of breed. The sound common sense which characterizes the American farmer forbids him to keep horses, cattle, or any other live stock merely for fancy. The open market is the ultimate arbiter of values, and it is by this test alone that pure breeds have come to their present established position in farm economy. Early maturity and quality are potential factors in determining a profit price, and so certainly do early maturity and quality inhere in breed that they can not be secured apart from the blood of the pure breeds, whether they be sought in the horse, cattle, or swine. * * *

If one chooses to acquire knowledge of breeds and their adaptations, and then has the decision and energy to apply his knowledge, he is likely to go in the direction where profit lies. Keeping improved live stock enables one to apply exact business principles to his farming. To illustrate: When live stock is the foundation of the farm economy probably half of the acres will be in permanent pastures. Upon these acres the stock will harvest the crop—converting grass into beef, mutton, speed, milk, or butter without any outlay of cash for labor. The remaining acres, devoted to a suitable rotation of crops, will secure stability in the farm operations, the capacity of the teams, the implements, and the men required this year being just what it was last year and just what it will be next year. The coarse products, such as straw and corn stover, which have little value as fertilizers when returned directly to the soil, have immense value when utilized by stock, the stover as food and the straw as an absorbent in the stables, while the labor required in the summer during the active operations of cultivating and harvesting will in the winter be profitably employed in the care and development of the live stock that during the summer has had the freedom of the pasture. On this farm there will be business the entire year; there will be no waste of products that have cost labor and fertility; the crops will go to the market in the form of beef, butter, speed, draft, mutton, wool, or pork, carrying with them the minimum of fertility. * * *

VALUE OF INFLUENCE OF PURE-BRED STOCK UPON THE INTELLECTUAL LIFE OF THE FAMILY.

Quite apart from the enhanced market value, pure-bred stock has another value which is not always estimated at its true worth—the value of its influence upon the intellectual life of the family. One only needs to go into the family home on the farm where pure-bred cattle, horses, sheep, or swine are reared to be convinced of the reality and the beneficence of this influence. If other proof is needed it may be had by comparing or contrasting a home on such a farm with one on the farm devoted to grain farming. It has been said that wheat farming debauches the mentality of the farmer. While this is probably too strong a characterization, yet it graphically suggests the mental vigor promoted by the life on the stock farm. There are some phases of the profession of farming not always well defined in our own thoughts; it is well worth while to consider some of these in their relation to the intellectual life of the farm family. For example, the circle of acquaintance and the associations which inevitably follow one's identification with any particular pure breed of live stock will widen the mental horizon; also the range of reading—

imperative if one would keep abreast of the advance being made by all the pure breeds—will itself strengthen the understanding and broaden the general intelligence. Then, too, the study of nature's methods, the mysteries of heredity, the influence of environment, bring one into intimate sympathetic touch with the great forces or laws that wait upon and reward our intelligence, or perchance punish our ignorance. The more than human response in affection and absolute trust which the horse, and even the Southdown, will make to the master's care teaches the highest lesson concerning our obligation to others. And all these lessons are so easily, so imperceptibly, transferred to other planes of life, where they influence conduct and destiny. When one appreciates intelligently and sympathetically the high privilege of controlling the conditions that create vegetable and animal life he may get a glimpse of that perfect love and perfect justice Divinity exercises toward its creatures.

INTELLECTUAL VIGOR IN THE FARM HOME.

If intellectual vigor is given an outlet on the stock farm, equally true is it that intellectual vigor finds a noble field in the farm home. There have been many definitions of the word "home," all showing some phase that appeals to the speaker. An inclusive definition is something like this: Home is a place and an opportunity for the complete development of the physical, mental, and spiritual natures, and inferentially for the sane enjoyment of life. The farm home offers peculiar opportunity for the development of the physical. This goes without saying. A happy childhood in the open air is the inheritance of the farm child, and the force of sunlight, pure air, and exercise are well-nigh conclusive in determining physical completeness. The nearness to great forces in vegetable and animal life, if at all utilized, must awaken powers of observation and strengthen the judgment by contemplation of cause and effect—the direct adaptation of means to an end so conclusively taught by the recurring seasons and the continuous round of animate and inanimate life must have incalculable effect upon the mentality.

SOUTHERN AGRICULTURE—MISSISSIPPI AND LOUISIANA.

PRODUCTION OF SOIL AREAS.

Prof. W. C. Stubbs, director of the Louisiana Experiment Station, began his address with a description of the geographical position of the States of Mississippi and Louisiana and said that one State is almost a reflex of the other, and the forces which produced soil areas placed on each side of the Mississippi River faithful counterparts. Louisiana has not yet reached maturity, for the Mississippi River is carrying to the Gulf and depositing soil material every year equal to over 1 mile square 300 feet deep. This river is gradually filling up the Gulf of Mexico and yearly extending the dominion of Louisiana. All of south Louisiana below Baton Rouge, known as the Delta Plain, with its immense fringe of coast marshes, is the outgrowth of the materials brought down by this great river. These recent additions to Louisiana have no counterpart in Mississippi, just as the earlier foundations in Mississippi find no corresponding representative in Louisiana. Agriculturally they are princely domains, Louisiana leading all States in the Union in the value per acre of products ($25), followed second by Mississippi with $19. Nature has blessed both States with a fertility of soil rarely equaled, never surpassed.

The speaker said that there were strangers present who might doubt the accuracy of such an assertion, and if so, he asked them to go with him over those States in a hasty examination of their resources, and he would guarantee conviction even though now surcharged with skepticism.

PRODUCTIVENESS OF THE MISSISSIPPI VALLEY.

Entering the mouth of the river they would find the far-famed valley of the Mississippi, with its numerous bayous, upon whose banks thousands of acres of sugar cane are grown annually, half a thousand central factories where the juice is converted into sugar, half a million people interested in the progress of this work, and half a million acres of the most fertile lands on the globe devoted to this crop, yielding over $25,000,000 annually. These lower alluvial lands are also well adapted to tropical fruits. Orange groves line the lower banks of the river, and thousands of acres of winter truck gardens and rice are to be found, giving support and comfort to many persons. Follow up these alluvial lands, go through the Red River valley of Louisiana, cross into the Ouachita, the Bouef, the Mason and the Tensas, of Louisiana, and the Deer Creek, the Sunflower, the Coldwater, and Yazoo bottoms of Mississippi, and everywhere will be found large and easily tilled plantations with palatial homes. To appreciate the nature and fertility of these soils, it is only necessary to watch the united waters of the streams hurrying past with a freight of sediment stolen from over a thousand townships. Take a glassful from yonder river and set it before you to settle, and you will find in the deposit a perfect museum of soils gathered from the fertile farms of New York and Pennsylvania, from the sandy cliffs of the great Kanawha, from the blue-grass regions of Kentucky and Tennessee, from the corn prairies of Iowa and Illinois, from the melon patches of the Cheyenne squaw, or from the canyons of the far-famed Yellowstone. Thus nature has robbed and is robbing the Northern and Western States of their finest soil material for the benefit of Louisiana and Mississippi. Under Southern skies these sediments, triturated, mixed, and deposited, make wonderfully productive soils. Louisiana has 20,000 and Mississippi 7,500 square miles of these soils, most of which can be made fit for cultivation under the present system of leveeing and drainage.

For rich alluvial soils, high above overflow, start at Baton Rouge and proceed continuously north until you have reached the city of Memphis; make frequent cross sections through this fertile belt, whose average width is about 40 miles, then cross the river into Louisiana, go to the Bayou Macon hills and follow them down to the Gulf; then turn westward into the Attakapas prairie, once the abode of Creole ponies and cows, now densely filled with the homes of many thousands of farmers and planters, like the soil they till, from a score of States congregated into villages, hamlets, and colonies.

Go into their fields and see how they have applied the mute instruments of human industry used in wheat farming to the more profitable cultivation of rice. You will see Iowa and Illinois reproduced, gilded by a glorious Southern sunshine. These prairies are fast becoming immense rice fields, and they are inundated by 260 miles of canal.

The speaker then suggested that perhaps his hearers would prefer to enter these States by land. If so, make a detour to the east and west of the Mississippi and proceed northward. There would be found inexhaustible forests of longleaf pine, dotted all over with steam sawmills, whose products reach by rail the treeless plains of the West and Rocky Mountain slopes and by water the States of Mexico and South and Central America. The last United States census estimated that there was nearly 50,000,000,000 feet of lumber in the forests of Mississippi and Louisiana.

Go farther north in both States until you reach the good uplands. There you will find well-tilled farms of red and gray lands owned and controlled by a sturdy and progressive yeomanry, where fountains of purest water gush from every hillside, and where fruits and vegetables are easily grown, and stock of every description cheaply raised. At Crystal Springs many girls are employed packing into crates the thousands of tomatoes and other vegetables which are shipped daily to western markets. Truck-growing on a large and profitable scale is fast monopolizing the attention of the farmers of this section adjacent to the great highways of travel.

Now go to northeast Mississippi, where there are immense stretches of cretaceous prairies with a variety of soils—black jack and bald prairies—all more or less calcareous clays of excellent fertility, bearing large crops of cotton; where the "melilotus alba" is preeminently at home, and where oats and hairy vetch furnish the finest winter pasture.

GREAT VARIETY OF PRODUCTIVE SOILS.

When you have finished this trip through these States you will have passed over a great variety of soils, each possessed of individual characteristics and at different elevations, yet all productive. The sections visited have the following areas: Alluvial lands, 20,000 square miles in Louisiana and 7,500 in Mississippi; bluff and brown loam, 5,793 in Louisiana and 8,200 in Mississippi; oak and hickory uplands, 8,103 in Louisiana and 5,830 in Mississippi; longleaf pine hills and flats, 10,138 in Louisiana and 14,800 in Mississippi; central prairie, 785 in Louisiana and 5,020 in Mississippi, and in Mississippi 5,990 in cretaceous prairies.

Such are the agricultural features of these States. Add to the fertility of the soil the numerous water courses and their railroad connections, insuring cheap transportation of all products, and their superb climatic conditions, and you have every requirement demanded by the modern tiller of the soil. These States grow almost every crop known to subtropical and temperate climates. Oranges, pomegranates, and figs are grown extensively near the Gulf, while wheat, barley, and rye are grown in the northern sections of both States. Truck-growing is an enormous industry along the lines of the North and South railroads.

THE FINEST COTTON IN THE WORLD.

The speaker remarked that it was useless and perhaps saddening to many present to announce that these lands will grow cotton. Unfortunately, the low prices prevailing were a strong reminder of the fact that this crop is grown in too great quantities, but it may be of interest to know that in 1879 Issaquena County of Mississippi, Chicot County of Arkansas, and East Carroll of Louisiana, produced the largest acre products in cotton. These counties are in the Mississippi basin, and represent the intersection of three States, and at this point is located the center of maximum production of cotton in the world. The cotton grown in these valleys is for "elasticity, length, and strength of fiber," pronounced the finest in the world, and its high appreciation by English and eastern spinners is attested by the constant attendance of their buyers in our markets. Corn and rust-proof oats, planted at the proper time and in the proper manner, can be grown in large and profitable quantities in every county. Rice culture is successfully conducted wherever bayous and rivers furnish irrigation water. Grasses and clovers thrive under the summer sun and winter sunshine. Alfalfa in the alluvial lands is a great success, often yielding 6 to 8 cuttings per year. All the distinct types of tobacco are grown in these States. The yellow leaf, used for plug and smoking, on the hills; the cigar type, of excellent quality, on the bluff soils; and the peerless perique upon the alluvial lands. Fruit culture is practiced everywhere. Our figs, pomegranates, and pecans are famous the world over; while peaches, pears, and plums are grown largely for the market in the northern portions of these States. Ramie, our vegetable silk, can be raised in large quantities. Both varieties of jute and several varieties of hemp succeed well. Forage crops of almost every kind, yielding several cuttings each year, are grown extensively over these States. The conditions for stock raising are remarkably favorable, as there is an abundance of cheap food, a continuity of green crops throughout the year, and a bountiful supply of water.

TIMBER OF ALL KINDS.

The forests teem with timber of all kinds. Over 60 per cent of the forest wealth of the United States is situated in the South, and of this amount these States possess the lion's share. It is distributed along the tributaries of the Mississippi and the Gulf of Mexico, and can thus be cheaply delivered to the markets of the world. Millions of dollars have recently been invested in these lumber resources, and the sawmills and planing machines of the North, like the cotton mills, are gradually moving South for larger profits. In cypress timber we stand without a rival, and our mills are putting annually upon the market nearly 500,000,000 feet of finished timber. Our oaks furnish an immense supply of staves annually to the foreign markets and our ash supplies the United States Navy, as well as the merchant marine, with oars. Our walnut, magnolia, beech, persimmon, gums, cottonwood, maple, etc., do or will supply many wooden-box or paper factories. Salt of the purest quality and in inexhaustible quantities has been found on the Five Islands off the Louisiana coast and elsewhere along the geological backbone of Mississippi. West of the salt deposits occur immense beds of gypsum and sulphur, together with flowing petroleum wells. Marls of high agricultural value have been found in many places in Mississippi.

Both States are blessed with thousands of miles of water courses, affording excellent facilities for getting our lumber and soils products to the outer world, and both States have an abundant supply of fish in the rivers, bayous, and Gulf.

But our largest natural resource is our location—situated on the Gulf, on both sides of the Mississippi River, connected by the latter inland with an immense territory stretching from the Appalachian to the Rocky Mountains and outward through its mouth with every port on the globe, it must be the gateway through which the exports of the entire valley, now populated with 30,000,000 people, must pass.

TOO MUCH LAND, TOO MANY MULES, AND TOO MUCH IGNORANT LABOR.

After this description of the agricultural advantages of these States, the speaker said:

> But some of our Northern friends may ask why, with all this agricultural wealth, we are not prosperous and contented? The reply can be formulated in a single sentence: Too much land, too many mules, and too much ignorant labor. The latter, as hewers of wood and drawers of water, roustabouts on our steamboats, cotton pickers, and saw-mill hands, etc., are the best laborers in the world. As adjutants to the progressive, intelligent farmer, they are valuable; but as independent, progressive farmers and as growers of diversified crops they are as yet a failure and will be for some time to come.
>
> With an excess of land, values are low, profits from hired unskilled labor uncertain. Cropping and renting, being a more certain revenue to those who hold large landed estates, are almost universally followed. Hence extensive planting of cotton, with acre yields rarely exceeding one-half of the natural capacity of the soil, and yet enough in the aggregate crop throughout the South to depress the price below the cost of production. As the negro is our laborer, so is the mule his constant companion at the plow. A hybrid, incapable of reproduction and unfit for the shambles, his only mission is to work and die. The losses incident to these two negative qualities in the use of the mule at the South aggregate in a year many millions of dollars. The mule must eventually go in any well-regulated system of farming. Our large estates must be disintegrated and divided, cotton must become a subordinate crop, and mortgages and deeds of trust obliterated from our public records ere the fullness of farming can be realized. We have reached the "parting of the ways," and must determine whether we will cling to old practices and become bankrupt or vigorously grasp the changed conditions of development and grow rich again.

EXPANSION IN THE FARMER AND THE FARMER IN EXPANSION.

AGRICULTURAL SCHOOLS.

Prof. William M. Beardshear, president Iowa State College of Agriculture and Mechanics Arts, in speaking on the subject of expansion in the farmer and the farmer in expansion, said in substance:

Science with practice in farming is recent not only in this country but in the world. The British National Board of Agriculture was not established until 1793, under the wise influence of William Pitt, the boy premier. The first three agricultural schools in the world's history, situated in Germany and Switzerland, were founded in 1799, just a hundred years ago. In this country agricultural education has its chief rise with the land-grant colleges of 1862. Yet the growth of these institutions has been most remarkable. The average farmer is liable to look at the college professor with his science as a kind of a strange animal coming down or rising up out of some mysterious region, and with it all impractical. Some of the professors have made mistakes on the other side, and have kept too great a distance from the practical needs of the farm furrows. They have not had their hearts enough in the work to make it plain and simple to the farmer of average intelligence.

SCIENTIFIC FARMING.

Dr. Jordan, of the New York Experiment Station at Geneva, employs a man to simplify the bulletins sent out by the various stations of the country so as to strip them of the unnecessary technicalities and make them understandable to the average population of the country. This is not peculiar to higher learning in agriculture. It is true in the development of all lines of new thought. But, on the other hand, too many farmers have talked too much about book farming and book learning and gone on in their old ways content to continue their backs to the light. These farmers have made the mistake of considering a few well-meaning yet stilted books, writers, and professors as excuses for excluding information and help from the realms of science. The college and the farm happily now understand each other better. Science is merely exact knowledge and sound sense. It is akin to the practical experiences of the intelligent man on his farm. Science is experience of the highest value. In the most progressive portions of our country through the growth of these recent years there are but few gaps left between the college and the farm.

As striking illustrations of the quickening and improvement of the implements of industry through cultured brains, the speaker cited the history of the evolution of the plow, and the invention of the cotton gin by Eli Whitney, a New England school teacher. He then said:

It remained for our country and Massachusetts to start the education of all classes, and the common-school system of the United States to lead the world in the leavening of the minds of the masses with the elements of education.

The most significant meaning of expansion to-day, not only in the farmer but among all classes, is that of the consistency and sympathy of education and labor. It is an accepted doctrine of long standing that the man who works with his brains and becomes a scholar is granted equal rank in society with the soldier, the men of state, of the professions, and wealth. A worthier acknowledgment is coming about in the world, which is that the man who works with his hands as well as with his brains, in accord with advanced industrial education of to-day, is entitled to first-rank admission among the best of the earth.

PROSPECTIVE SHORTAGE IN WHEAT SUPPLY OF THE WORLD.

The speaker referred to the marked sensation produced in scientific circles in England recently by the address of Sir William Crooks, president of the British Association for the Advancement of Science, who asserted that within the near future the world will be stared in the face with a grievous shortage in the wheat supply, and said that Mr. John Hyde, statistician of the United States Department of Agriculture, had made this address the basis of a very suggestive study of America and the wheat problem. Mr. Hyde makes a very thorough and substantial presentation of the wheat problem in the United States for the present and coming generation. By 1931, in the reasonable reach of the activities of the younger portion of this generation, the population of this country should be about 130,000,000 people. According to census reports this would, as Mr. Hyde says, make demands upon our resources—

> to include a wheat crop of 700,000,000 bushels, without a bushel for export; an oat crop of 1,250,000,000 bushels; a corn crop of 3,450,000,000 bushels, and a hay crop of 100,000,000 tons, all for domestic consumption; with cotton and wool, fruit and vegetables, dairy and poultry products, meats, and innumerable minor commodities in corresponding proportions. The area necessary to the production of the three principal cereals alone will be over 15 per cent greater than the enormous total acreage devoted in 1898 to grain, cotton, and hay, while the mere addition of the two last-mentioned products and of the minor cereals will call for an acreage exceeding the total area of improved land in farms at the present time.

This could be overcome by growth in acreage of production. This growth in acreage in proportion to the inhabitants is already decreasing and will decrease much more rapidly in the next thirty years. Diversified farming will do much to help out these conditions, but this will not be sufficient to meet the demands. Scientific agriculture will come in as a significant factor in this remarkable calculation. All these considerations with reasonable certainty foretell the time within the reach of the present generation when the chief reliance must be upon the science of American farming.

Industry must be fortified with a superior intelligence, a skill wrought out on the farm, in the laboratories of the agricultural colleges and experiment stations, and the wise fostering of our national Department of Agriculture. This means a thoroughly enlightened farmer at the end of the next thirty years.

The spirit of expansion is not only in the air, but, better, it is in the farmer himself. As a result of this expansion in the farmer, he will have better confidence in himself and in others than he has had in the past. Knowledge, science, and experience join interests to make man at home in all callings.

HIGHER EDUCATION FOR THE FARMER AND MECHANIC.

The speaker said that this expansion has brought higher education to the farmer and mechanic. The National Government has sixty-four colleges and universities devoted exclusively to the higher education of the young farmer and mechanic. From these the graduates in agriculture are now rapidly mounting by hundreds each year, and at the present time there are about 4,000 students in these institutions engaged in the higher education of agriculture. Of all the people having gainful occupations in our land, 36 per cent are farmers. One-third of the population and one-fourth of our national wealth are in the direct interests of agriculture. In one year the products of these farms amount to $2,460,000,000. A vast majority of this marvelous percentage of population is wholesome bodied and sound minded. They are the reservoirs of much of the physical, mental, and moral energies of the cities. They are the conservators of patriotism, industry, and thrift. They are just getting a taste of education applicable to their industries, their home, and their civilization.

AGRICULTURAL PUBLICATIONS ISSUED BY THE GOVERNMENT.

Of the value of the publications the speaker said:

> In the past few years 6,663,000 farmers' bulletins of the most careful and scientific production and editing, and bearing upon practical questions of farm industry, have been distributed among the farmers of the United States.
>
> A Yearbook, a superb volume of about 800 pages, brimful of practical matter to the farmer and with science adapted to his understanding, is issued free in an annual edition of 500,000 copies. The rate of increase in the publications of the United States Department of Agriculture has been so great during the last five years that if continued until 1901 the total number of copies will reach 16,000,000 and soon make it possible for the 5,500,000 farms in the United States to have immediate touch with this uplifting and inspiring information. In addition to this work of the Government, periodicals of State and national reputation are devoted exclusively to the various aspects of agricultural industry. The experiment stations of the various States and Territories issue annually about 450 bulletins treating upon the subjects of special scientific and local interest throughout the States. In addition to this an agricultural literature has sprung up in book lore that is finding its way to the more progressive farmers.
>
> As effect follows cause, so surely will this beneficent aid of the Government and the universal intelligence of the American farmer bring a marked advance in all educational lines of his calling in the near future. * * * Daily rural mails, which are sure to come, good country roads, and in thickly populated districts of the United States electric railway connections will combine in the early decades ahead to speed education in agriculture and the intelligence of the farmer.

HORTICULTURE.

FRUITS AND OVERSTOCKING.

Hon. G. H. Van Houten, secretary of the Iowa State agricultural society, said that in its original meaning the word horticulture seemed to signify a garden, but in recent years it takes in not only the garden, but the small fruits, the orchard, and even the landscape, for we hear much of landscape gardening, and that one branch of horticulture has engaged the attention of some of our best writers.

The subject of horticulture is one that is inexhaustible. The changing conditions, the development, the different climatic conditions, the new varieties being propagated, the changing fashions—for fashions change in horticulture as well as in other things—render the study and practice of horticulture one of the progressive arts or sciences.

We learn from sacred history that horticulture was the first occupation of man. It is true that the first orchard was not planted by man, but he was commanded to dress and tend the garden.

During the many centuries when men were tearing down rather than building up, the fruits that must have grown on every hand were neglected and destroyed, and little but wild fruits remained.

Few localities are supplied with fruits of all kinds during the season, to say nothing about a home supply after the season of the particular fruit has passed.

It may be answered that prices are low and at times the markets have been overstocked. As a matter of fact, compared with the cost of production, prices for fruits have averaged above the prices of grain and stock. It is certainly true that the gluts in the markets are in a great measure due to faulty distribution. Fruits, more than any other products, must find a ready market, and must be disposed of soon after being received from the grower. With more systematic handling, cold storage, refrigerator methods of transportation, and more attention paid to finding markets there will be less overstocking, fewer losses, and more satisfaction to growers, dealers, and transportation companies.

The speaker said he did not assume to know the subject sufficiently well to deal with horticulture in all its different phases and for all of the territory represented by delegates to the meeting.

He would therefore not attempt to handle all the subtopics of the matter under discussion, but would speak from the standpoint of experience, more particularly as such experience had been gained in his own locality and in the fruits that do well in the State from which he came.

Apples.—Of all the fruits of the temperate zone none surpass the apple in importance. The varieties are almost without number, and are being constantly increased by scientific pollination. There are early nd late varieties, so that with proper management fruit in its natural te can be had every day in the year. Not only can apples be kept in the natural state, but they can be evaporated, dried, canned, preserved, and put up in various ways, to say nothing of the processes of expressing the juice and making it up into butters, etc.

In the Northwest generally too great a proportion of early varieties is planted. A selection should be made that will bring apples early, and then a succession during the entire season, with a goodly number of trees of long-keeping varieties to last over winter. It is not necessary to have cold storage for this, for caves are found to be an excellent and cheap means of keeping apples. If the caves are deep and with sub-earth ventilation the best results will be obtained and at small cost. If made of brick or stone or other substantial material they will last as long as required, but even if built of hard wood they will last many years. The great difficulty is to keep rats out of wood caves. Some good caves are made of concrete blocks or slabs, formed so as to make a cave shaped like a cone, with a door on one side with steps, and double doors to keep out the cold.

In the selection of varieties of apples for planting the safest rule that can be given is to plant those varieties that are known to succeed in the locality where you desire to plant, and especially on similar soils and exposures.

It is all right to experiment, and under conditions likely to prove beneficial, experimenting should be encouraged, but ordinary experiments are neither profitable nor educational, for the reason that they are not systematic and are not reported with such care and correctness as to be valuable. The experiment stations are better equipped for this work than the average individual and have better means of disseminating the results of the experiments.

Pears.—Pear growing has not proved successful generally in the North, and except in a few localities has not been a success with individuals. It may be that with the introduction of foreign varieties or by seedling production, varieties may be obtained that will thrive. Blight is the present cause of failure, and until nonblighting varieties are obtained the whole northland will import pears or go without. There is a great demand for pears, and if they can be supplied of a good quality at reasonable prices a good steady market is assured.

Peaches.—Peaches are grown successfully as far north as the forty-first parallel of latitude, and yet there are but few places so far north where they thrive and are anyways certain to produce a crop. Peach trees live and some of the hardier varieties bear as far north as north central Iowa, but some years, even in latitudes much farther south, and frequently over limited areas, the frost kills the buds and the trees fail to bear. Therefore, unless much hardier varieties are produced and more favorable conditions exist, there will be a demand for fruit, and those who live farther south will find a market for their peaches.

Apricots.—Some of the Russian varieties seem hardy enough to endure the rigors of climates as severe as that of central Iowa, but little of this fruit is grown. The question of stocks for half-hardy and tender fruits has not received the attention it deserves. When it is taken up and studied it is quite probable that there will be a great increase of productiveness and fruitfulness. The question of adaptability of stocks to scions, or as it is often termed *congeniality*, is receiving a little attention and will receive more as we gain experience and have time to turn our attention to these more intricate matters in horticulture.

Plums.—None of the wild or native fruits of North America surpasses the plum in variety or excellence, and the American varieties can not be displaced by any of those introduced from Europe, Asia, and the islands of the sea. Foreign varieties may be larger and more showy, but they can not equal the native in quality. Their great variety, their excellence and their reliability leave little to be desired in the way of season and quality, and some of the newer varieties propagated by enthusiastic growers are approaching in size the foreign varieties. The plum, unlike other native fruits, has a wide area, and endures the heat of the South and the cold of the North, so that native varieties can be found that will meet the requirements of any special locality from the Great Lakes of the North to the Gulf of Mexico. The Chicasa varieties are not as desirable for the North as those known as *Americana* varieties.

Crosses and hybrids of the native plums and varieties from Europe, and more particularly from Japan, are so promising that many active experimenters are giving considerable attention to this branch of horticultural work. No matter how good the quality of a fruit may be, if the size is small there will be a demand for something larger. This opens up a field for experiment, and encouragement should be given to those who desire to produce new varieties.

Cherries.—Unlike plums, the native cherries of North America have never become popular, and yet it may be found necessary to use the *Prunus pennsylvanica* as a stock for the red cherries of Europe. Experiments along this line indicate that it will pay to do so. There is a long list of varieties, and the range of size, season, and quality enables the planter to make a choice with the hope of getting just what he desires. Some of the varieties are not hardy enough for the north, but there are many that are hardy and of good quality. Others do well farther south, so that varieties may be found suited to the especial requirements of the planter and the place in any given locality. The cherry is becoming one of the popular market fruits, and many large orchards are being planted, so that it is safe to assume that there will be a large increase in this palatable fruit. The speaker has not given up hope of getting something good in cherries from Japan. The cherry is one of the most popular, if not the most popular, tree for park lanting in Japan. The trees are hardy, grow to large size, and afford usion and variety of bloom that is surprising. If the importations do not give us what we want, then seedlings should be planted or crosses procured so that we may try to get some of the desirable characteristics of the Japanese varieties. This is a field for experiment that has not received the attention it deserves.

The speaker said:

> The plums in Japan have a season and variety of bloom that is perfectly astonishing, and the fact that the fruits in Japan stand quite hard freezing when in bloom seems rather strange when we consider that the weak point in growing such fruits in the United States is from the supposed tenderness of the bloom. In Japan for days and nights together I have seen ice form to a considerable thickness, and yet the tree blooms seemed to endure it without injury. In the United States we always hear that the Japan plums fail because of spring frosts.
>
> Time will not permit me to discuss all of the fruits that will do well in even a given locality, but the growing importance of at least one of the small fruits induces me to name one in this connection.

Strawberries.—Inasmuch as the strawberry is easily grown, that it can be grown almost anywhere, that there is scarcely any limit to the distance it can be shipped by rail, and that the seasons are such as to encourage the growing of the fruit in one climate to supply it in a fresh state to persons living in other climates, make it one of the most popular and profitable market fruits.

There are localities that ship hundreds of carloads of berries during a season, and some of them are greatly increasing their acreage. In the busy season in Missouri ten thousand pickers may be seen at work in one locality and the berries going out by the carload.

Texas, Florida, Mississippi, and other States south begin in the winter to ship berries north, and as the season advances the growers farther north begin to supply the demand, and as the sun advances toward the north the berries ripen, until in the summer time the Northland comes up with its crop of this delicious fruit. Strawberries grow even as far away to the north as Alaska. With the many good varieties any given locality can be supplied with this splendid fruit.

What has been said of strawberries can be said to a less extent of raspberries, currants, gooseberries, blackberries, and other small fruits.

BAMBOO.

The day will come when all of our Southland will grow the bamboo. Travelers in the far East, and especially in Japan, are impressed with the importance of the bamboo. It is used for almost everything, and is profitably used too. It can be grown so easily and in such profusion that when we begin to study economy, as we must some time, we will raise bamboo in all localities where it will grow. It thrives wonderfully well as far north as central Japan, and we are led to believe that it will thrive in the Southern States as far north as Tennessee. It grows to considerable size even as far north as the latitude of southern Iowa, but Iowa winters are too severe for it.

It would flourish in the South, and it is susceptible of so many and such varied uses that it must be seen and utilized to be fully appreciated.

AGRICULTURAL EDUCATION.

ENDOWMENT OF AGRICULTURAL COLLEGES.

Agricultural education was the topic discussed by Prof. William M. Liggett, dean of the College and School of Agriculture of the University of Minnesota. He referred to the passage in 1862 of the bill introduced by the late Senator Morrill and passed by Congress, granting 11,000,000 acres of the public domain for the purpose of endowing an agricultural college in each State in the Union; the passage in 1890 of the so-called Morrill bill making appropriations from the sale of public lands to supplement the income from the original grant; the liberal appropriations from State treasuries for buildings, equipment, and running expenses, and said:

> With such endowments it is not unreasonable for the public to look for results, and to be disappointed when Senator Morrill's dream of the practical school of agriculture did not rapidly materialize.
>
> The evolution of the now popular idea of practical courses of study in agricultural schools has been slow. Half a century ago all school methods tallied with the idea that learning was for the few. The modern idea is to diffuse knowledge and give rich and poor equal opportunities for individual development and advancement. This is in such close accord with American sentiment and theory of American government that it only needed to be proposed to be generally adopted.
>
> Now, the States have opened all doors, from the district schools to the university, on the theory that ignorance is the enemy of the state and a menace to popular government.

It is unfortunate that the swift movement toward popular education was not quickly followed by a radical revision of school methods. The old machinery made to grind out doctors, lawyers, and preachers has continued too long and the grist has been a disappointment.

The city has grown at the expense of the country. The brightest young people have left the farms, the standard of country living has been lowered, and the professions have become so overcrowded that the surplus is a burden to society. But common sense has been too strong for old traditions, and it is now generally admitted that if education is to be universal, or even general, it must be along practical lines, and that school is counted the best which, while developing a well-rounded character, best fits the student for his chosen calling.

To be successful a school of agriculture must command the respect and approval of those most interested in the work, and with a school planned and conducted on right lines the problem how best to extend its usefulness is greatly simplified.

MODERN IDEA OF PRACTICAL FARM EDUCATION.

The speaker said that by way of illustration he would refer to some phases of experience in the Minnesota School of Agriculture as a fair embodiment of the modern idea of practical farm education. This hool was among the first to adopt a practical course of study and practical methods of instruction. A very large percentage of the graduates follow agricultural pursuits, and the people of Minnesota are well-nigh unanimous in its support. Its success in these particulars is phenomenal and worthy of careful study.

The foundations of the school were carefully laid along practical lines. The location chosen was the State Experiment Station, where during the entire year the teaching force carry on actual experiment work and gather material for use in their no less important capacity as teachers in the winter school. This close alliance of the school and the station is a strong point, and as the station is near the university (of which the School of Agriculture is a department), the fine equipment of that liberally supported institution is always at command for the use of both students and faculty. As the prospective students would be from the farm, the sessions were made in winter, the season of comparative leisure in the country. Dormitories were built calculated to bring the students in closer touch with the faculty and teaching force; and to create a school home and home life, a liberal table was provided at cost; a simple gymnasium was provided, and military drill and physical culture required.

The course of study aims to supplement what the student already knows, and at the same time to thoroughly cover all lines of agricultural work.

Thoroughly practical methods of teaching are followed, and the aim is to teach the one best way of doing a thing and clinch the lesson by giving the reason for it, thus training the mind of the student to search for those fundamental principles which, in the future, will be needed to direct him in the conduct of independent investigations.

In the side lines that bear a close relation to farming enough is taught for practical use. In blacksmithing the student learns to make all ordinary repairs to farm implements. In carpentry he is taught the use of tools and how to construct ordinary farm buildings. In horticulture the management of the farm garden is completely covered. In dairying the student follows the whole process of butter and cheese making from the cow to the completed product ready for shipment, and learns the use of every implement employed. In entomology he learns to know insect friends and enemies, and how to protect one and destroy the other. In chemistry he learns the composition and values of the feed which his live stock consumes, and how to analyze the soil he tills. In botany he learns the laws which govern plant growth, and gets the key to the best methods of culture. In the veterinary class he learns how to treat the common diseases of domestic animals and something of simple surgery, and in the broader study of agricultural work the best method of culture and use of farm implements. In live stock, judging animals is thoroughly taught, and the science of feeding is made an exhaustive study. Slaughtering animals and cutting and curing of meats is explained to an extent covering the needs of an ordinary farm. All these lessons are clinched by actual work. The student is not only told how to do things, but is required to do them under the eye of a careful and intelligent instructor.

METHODS OF TEACHING.

The speaker said that, as an illustration of the methods of teaching, a class in live stock might be mentioned. A cow, for example, is brought in. Many students when they reach the school think they know all about cows and need no introduction to them. But when the cow before the class is analyzed, her faults shown, her good points made known, and the ideal cow made plain to the mind's eye, a new interest is aroused, and when later the student is required to judge a different one, applying for himself the principles taught, the practical lesson is fixed in memory beyond any probability of losing it. And when he is led on into the science of feeding and learns that kindness, comfort, and shelter pay, and that feed not needed is worse than wasted, and that want of a properly balanced ration is partial starvation, he begins to understand that he knew a very little about cows, and what was perhaps distasteful before takes on a new and intense interest.

The same line of instruction is followed in other departments. The lessons taught in all the class rooms are so clearly practical and valuable that it is seldom that an experienced farmer visits the school without saying, "If I could have had such instruction when I was a young man it would have saved me thousands of dollars."

But, however wisely the foundations of a school are laid, its success depends upon its teaching force. That of the Minnesota School of Agriculture is a harmonious body, working together for the single purpose of winning success for the school, and each member is an expert and an enthusiast in his or her line and in full sympathy with rural life.

It is of no use to have instructors to teach young people what they do not believe themselves, and the best teachers are enthusiasts who can inspire everyone around them with something of their own sentiment.

THE SCHOOL MUST KEEP IN CLOSE TOUCH WITH THE FARMER.

The school of agriculture which expects to grow in attendance and influence must keep in close touch with the intelligent and progressive farmers of the State. No dean or professor is so wise or well equipped that he can not learn something from the men who walk between the handles of the plow and put all theories to the test of actual practice. It is a pleasure to acknowledge that many of the most practical features of the course of study at the Minnesota school are based upon suggestions from farmers whose wisdom came from the fields.

TO CHECK THE TENDENCY CITYWARD.

Whether schools of agriculture will check the migration of the bright young men and women from the farms to the cities remains to be seen. It is not expected, nor is it desirable, that all graduates of these schools should remain on the farm. Some are unfitted to be farmers, and if such choose a calling that is distasteful to them the calling is discredited and the individual is hampered by an uncongenial employment. To check the tendency cityward, schools of agriculture should present the attractions of the country in new and favorable lights, so that the substantial advantages of rural life will not suffer by comparison with the more brilliant but illusive attractions of the city. All the systems of education, including the country school, have in the past educated children away from the country. One of the missions of the school of agriculture is to make the country home stand in its true relation to wholesome living, and to enable young people to decide fairly and intelligently between the country and the city.

Fortunately the students in these schools are good material to begin with, and most of them are studious, ambitious, and self-reliant.

What an uplifting force will be developed out of these centers of influence as the graduates year after year assume their duties as citizens and found new homes can hardly be imagined, but that it will be a powerful factor in placing agriculture in the front rank of industrial progress does not admit of a doubt. For myself, I look forward to the future of schools of agriculture with a confidence which I believe is fully warranted by the success already achieved, and expect to see their influence steadily increase and widen until the effect of their good work becomes more and more apparent in the betterment of conditions on the American farm and the general uplifting of this the most important class of the world's workers.

STOCKS AND FEEDS TO FEED THEM.

LOSING MONEY GROWING COTTON.

Prof. W. C. Welborn, of the Agricultural and Mechanical College, Mississippi, said he attended a farmers' institute last summer in one of the hill counties of Mississippi, where, like all other parts of the State, the people depend on planting enough cotton to buy money or credit enough to buy a living with. He wrote down all the items of expense incurred in growing cotton, from the preparation of the land to the marketing of the crop and farmers present filled in the figures. The average yield in the county was one-third of a bale per acre and the expense footed up $12. The cotton and seed at the prices then prevailing amounted to $9.35, making a net loss of $2.65 on every acre of land growing cotton.

A few days before the present convention he was at a large farmers' meeting at Magnolia, Miss., where the people were earnestly asking what they should do to be saved from bankruptcy. He repeated the inquiry as to the cost of growing the great staple at the rate of yield there prevailing, which was likewise one-third of a bale per acre. The expense column footed up $10.85. Deducting from this the value of the crop, the net loss was found to be $1.50 per acre, or $4.50 per bale, on all cotton raised in Pike County. At this same meeting it was shown that a bale of cotton per acre would give a profit of $11.35, but the people said they could not make a bale of cotton per acre except on a favored spot now and then—that they could not make it even with a large amount of purchased fertilizer.

Only small applications of concentrated manures are found profitable. From long-continued cultivation in cotton, the land has lost its life-giving vegetable matter, or humus. It will not hold enough water to supply the yield of crops that large applications of fertilizers should give. The land needs a rotation of crops, including leguminous crops and pasture grasses, and should be devoted to the live-stock industry, instead of cotton, the lint and seed of which are shipped to distant States and countries.

For the benefit of those persons who think that the agriculture of the State is diversified enough, the speaker said that of the crops grown in Mississippi in 1898, the value of which he had roughly estimated at $50,000,000, he could not find in any statistics at command enough crops other than corn and cotton to make $5,000,000 in value. With a climate and soil admirably adapted to hay grasses and forage crops, Mississippi raised in 1890 less than 100,000 tons of hay; with the finest land on the globe for fruits and vegetables, she produced less than $250,000 worth; and with the far-famed cowpea, the clover of the South, the easiest of all crops to grow, the greatest fertilizer ever given to man, a stock food second to none on earth, but 240,000 bushels had been grown that year, when 10,000,000 bushels should be grown.

MISSISSIPPI AND IOWA PRODUCTIONS COMPARED.

He said that in order to get at the truth of the matter as to whether Mississippi is as prosperous as she should be, he would briefly compare that State with one of the Northern States having a smaller agricultural population.

In 1890 Iowa farmers worked 25,000,000 acres of land; Mississippi farmers, greater in number, worked but 7,000,000 acres.

If Mississippi raised $50,000,000 worth of field crops last year, Iowa, as estimated, raised no less than $120,000,000 worth. In 1890 Iowa produced 500,000,000 gallons of milk, worth $40,000,000, as compared with $4,000,000 in Mississippi. The people of Iowa in 1890 had in round numbers 22,000,000 fowls, laying eggs valued at $7,000,000. Mississippi had 6,000,000 fowls, laying $1,000,000 worth of eggs. The statistics available did not give the annual supplies of pork, beef, mutton, etc., for slaughter, half of whose value no doubt came from pastures the product of which were not otherwise enumerated. Considering these items the conclusion is irresistible that each Iowa farmer's income three times that of the Mississippi farmer.

In 1896 the people of Mississippi owned 291,000 milch cows worth less than $13 each, and 446,000 other cattle worth $8 a head. Iowa people owned 1,200,000 milch cows worth $28.50 each and 2,200,000 other cattle worth $25 a head. Mississippi's 2,000,000 razor-back hogs were worth $2.40 each, while Iowa's 3,750,000 hogs were worth $6.

Of hogs, cattle, and sheep Mississippi has $12,000,000 worth and Iowa $112,000,000 worth, or nearly nine and one-half times as many. Who can wonder that Iowa's per capita wealth is $1,200, while Mississippi's is but $350, and the total wealth of the former State is five times that of the latter?

MIXED HUSBANDRY AND DIVERSIFIED AGRICULTURE.

The speaker said he believed that mixed husbandry and diversified agriculture, in which enough stock is kept to consume most of the products of the farm, are largely responsible for the excellent showing made by the Northern sister State as compared with his own State. In Mississippi a system of ill-advised, badly balanced, lopsided farming is followed that enables a hand to wear out about 15 acres at a time.

They now grow mostly a crop requiring an immense amount of human labor, the most expensive factor that enters into any business. The culture of cotton, allowing the land to remain bare all winter, has so facilitated washing and leaching of the soil during open winters as to well-nigh ruin much of the best land God ever gave to any people.

Much of the land has become so infertile and the price of cotton so low on account of too exclusive culture that landowners can not make day laborers' wages for themselves and families while growing it. Necessity is moving the people as never before to find new crops and new products to divert some of the labor and utilize the lands. A better-balanced system of agriculture is needed—one that will include more crops to enrich instead of wear out the lands; one that will include more live stock to consume the products and manure to still further enrich the soil. Such a system, if intelligently planned, will enable each farmer to profitably utilize 3 acres where he now loses money on 1.

ROTATION OF CROPS.

By a suitable rotation of cotton, corn, and peas, oats and peas, hay grasses and pasture, every acre of run-down farms might in a few years have its producing capacity more than doubled. With plenty of stock, feed stuffs may be grown on the least desirable parts of the farms and fed on the most desirable, and thus have the fertility moved, in a measure, to where it is wanted.

From the earliest times it has been known that one crop would in some way prepare the land for making another crop. In the light of modern science it is now quite well known that certain plants draw on the atmosphere for definite quantities of nitrogen whose compounds make our most nutritious feed stuffs and our richest fertilizers, and the amount and value of which may be computed as accurately as may be the value of a bale of cotton or a load of corn.

WHAT WAS RAISED AT THE LOUISIANA EXPERIMENT STATION.

Dr. Stubbs tells us in a bulletin soon to be issued from the Louisiana station that an acre of Spanish peanuts grown on poor pine lands at Calhoun, La., contained 192 pounds of this nitrogen, worth at commercial fertilizer's value at least $25. An acre of velvet beans contained 191 pounds, and an acre of cowpeas 108 pounds. These crops made from two to three and a half tons of feed stuffs richer in food elements than wheat bran. When they can be fed to stock without serious loss of fertilizing value is there any excuse for having poor land and poorer stock? Professor Duggar, at the Alabama Station, found an acre of Spanish peanuts on poor gravelly land produced 600 pounds of live weight of hogs, and an acre of cowpeas about 400 pounds. No country on earth has such advantages for growing restorative forage crops, and yet no country makes so little use of them. By a simple rotation of crops, with a very moderate application of mineral fertilizers, the poorest farm in the State may soon be built up to where it will produce 40 bushels of corn or a bale of cotton with as much ease and certainty as the great Yazoo Delta. Dr. Stubbs did this at Calhoun, La., on land showing by analysis extreme poverty.

By rotating cotton, corn, and peas, and oats followed by peas the same season, he brought the cotton up to a bale and over, the corn yield to 37 bushels, and the oats in one case to over 60 bushels, and pea-vine hay to 2 tons. To inaugurate such a practice it is only necessary to divide the farm into three parts, plant the three crops, and let them follow each other in the order named. This could be practiced by every farmer, however poor. Such a plan would in a few years regenerate the worn lands to where the one-third of the farm planted in cotton would yield as much as the two-thirds or three-fourths in cotton now yields, the expense would be cut in half, and the profits would become real. With two-thirds or more of the farm in food crops, and with live stock to consume it, they would naturally find it convenient to provide ample pastures and broad meadows, and thus would they find another profitable means of reducing the cotton acreage. Then would one hand in Mississippi utilize as much land as a hand in Iowa, and the income be multiplied by three and the land quadrupled in value.

Under a system of rotation with the legumes the poorer lands of Mississippi would need only acid phosphate, and by the use of acid phosphate on these lands the yield of peas would be doubled, and thus twice the amount of nitrogen would be drawn from the air.

Even better results can be obtained in the way of feeding lands and live stock at the same time than has been indicated. Mississippi has more than one winter-growing legume that will prove an entire success for every part of the State. Scientists have demonstrated that the germs that enable certain crops to feed on nitrogen from the air can live and work and grow all of the southern mild winter.

The professor said that on the 10th of February, just one year ago, he picked a square yard of bur clover and had it weighed and analyzed. Calculated to an acre, the above-ground portions contained as much nitrogen as 1,000 pounds of cotton-seed meal would furnish and enough dry food to support a thousand-pound cow eighty days. An experiment with hairy vetch showed as much nitrogen as 1,100 pounds of cotton-seed meal would furnish and enough dry matter to feed a cow one hundred and thirty days.

GROWING LIVE STOCK.

The professor said:

> We can keep our lands busy twelve months in the year growing fertilizers and feed crops. We can grow the fertilizers in winter for our regular spring crops and feed our stock to boot. As to whether we can grow as fine cattle as the North, there is considerable doubt in the minds of some of our people; but I have no doubt, in fact I know we can do it. For some years we have grown hogs to weigh 200 pounds at six months with an ease and cheapness you know not of in the North. Our green winter crops we find make from one-half to three-quarters of the food of hogs and cost nothing. Our people are everywhere admitting now that we can raise the hogs, but there is yet doubt about raising a large, quick-maturing, high-priced steer. But this can be done. Last fall we weighed a number of spring calves that had run with their mothers, and there was not one that did not grow 2 pounds a day or more all through the summer. I wrote to a number of St. Louis and Chicago live stock commission companies and asked them what good, well-marked, grade Hereford, Shorthorn, or Aberdeen Angus calves, eight months old and weighing 500 pounds, would bring in those markets November 15, when the quarantine against our cattle is raised. They invariably replied, if they show good blood, they will bring a round 5 cents a pound to go to the farms as feeders. Just think of it! An eight-months old calf bringing $25. Why, our two-year olds, the way we grow them, bring $5 and $6 a head.

CROPS AT THE COLLEGE FARM.

The speaker said that on the college farm the whole face of the earth is covered with green crops, principally turf oats and hairy vetch. When once started these crops never have to be resown, and the vetch is whipping the oats out, taking field after field. About 500 acres are clothed in green. Green crops keep the lands from washing and leaching during the warm, wet winters, as these causes have done five times as much to wear out the lands as all the crops ever removed from them. These crops are being sown between the rows of corn, cotton, sorghum, peas, etc., at laying by time. If every cultivated acre were so treated in Mississippi, and the resources for growing food fully developed, she could grow the beef of Iowa, the dairy products of Wisconsin, the pork of Illinois, and the mutton and wool of Ohio.

A great deal of sorghum was planted about August 1 to 10 last year on land made rich by vetch. From August 1 to November 1, between the first frost of Minnesota and that in Mississippi, as high as 23 tons of green sorghum per acre were grown, curing out as high as 5 tons of hay-dry forage, making 8 or 9 tons of juicy hay ready to stack or house. Most of this sorghum crop was put in the silo just after the first freeze—November 1. The cost of the sorghum silage, from breaking land, buying seed, and hauling the cane an average of 1½ miles, was 50 cents a ton. Some of the crop was cut for hay and allowed to lie one week, drying out enough not to sour after it was stacked and housed. The speaker said that he never saw better hay; stock eat every shred of it. In fact, when he left home a week ago it was as sweet as sugar and juicy enough to chew. When cut late it will remain succulent all winter, and does away with the necessity for a silo. Grown as a second crop, it need not cost $1.50 per ton to grow this splendid hay. It will lie a month in the usual dry November, and will stack better than any other hay.

VARIETIES OF HAY CAN BE GROWN.

Hairy vetch, or turf oats and hairy vetch mixed, cut for hay about May 15, make a hay not inferior to red clover or alfalfa. Early varieties of cowpeas will make a crop of hay in two months. By following vetch hay with early cowpeas for hay the land can be ready for sorghum hay by August 1 to 10, and if 10 tons to the acre is not grown there will be nearly that much. Thus for nine months in the year crops that draw nitrogen from the air will be grown, and much of it will be stored in the roots and stubble and in the adjacent lands. In three months it will be pumped out by that grossest of all feeding stocks, the sorghum, and fed to stock.

In conclusion, the speaker said that he believed that with the help of such meetings, with the help of the stations and colleges, and with the help of the Department publications, which are indipensable to him, that they would work out their great industrial problems.

THE PECULIAR ADVANTAGES OF THE SOUTH FOR GROWING FORAGE CROPS AND FEEDING STOCK.

POSSIBILITY OF RAISING HIGH-GRADE ANIMALS IN THE SOUTH.

Prof. W. R. Dodson, botanist of the Agricultural and Mechanical College of Louisiana, said that other speakers had told how to select animals and how to breed them; the nature of the food and how it should be fed; and the care stock should receive, and the results that should be obtained. It remained for him to tell that all this can and should be done most successfully in the South, especially in the States of Mississippi and Louisiana. He would devote the time allotted to him to a brief discussion of three questions:

1. The possibility of raising high-grade animals in the South.

2. The advantages in the way of cheap feed and the economy in the care of stock.

3. The question of marketing.

The South has never produced even its own supply of meat, horse power, or dairy products, and has been largely dependent upon the States North for mules and horses to perform plantation work. Enormous quantities of salt pork, bacon, and beef have been imported annually. Kansas and Nebraska furnish a large portion of the butter used. The beautiful horses that prance on the streets are nearly all brought from other States.

The speaker asked why this state of things should exist. He believed that these animals could be reared from birth within the confines of the Southern States.

Horses brought from other sections suffer but little inconvenience in becoming accustomed to the climate, and mules know but few ailments. There is no reason why hogs can not be raised in the South. Less than two weeks ago a dressed hog was sold at the Baton Rouge market which tipped the scale at 800 pounds. This shows that hogs can be raised in the South to any size desired. They are robust and healthy and all breeds find a congenial home.

RAISING CATTLE FOR BEEF OR DAIRY PURPOSES.

The raising of cattle for beef or dairy purposes is a more serious question. There are some obstacles in the way, but they are not insurmountable. Northern-bred animals imported for the purpose of improving herds are subject to Texas fever, which is very fatal to adults. The great losses from the disease has perhaps more than anything else discouraged the improvement of stock in the South. As is well known the Southern cattle tick is the conveyor of this dread malady and is the only means known for the transmission of the disease. It has been demonstrated that pastures can be freed from the tick by not allowing cattle to run on the land for one year. A large percentage of young animals recover from the disease without treatment and from these it is possible to build up immune herds. There also appears to be a fair promise that the fever may be prevented by protective serum inoculation.

The speaker said he believed that when the roaming at large of cattle ceased in the South the tick question will become far less formidable as an obstacle to successful stock raising. He concluded his discussion of the first question with the assertion that the careful, intelligent, and diligent stock raiser need not suffer any loss from Texas fever, and that the best blooded horses, hogs, and cattle can be raised in the South.

ADVANTAGES FOR ECONOMICAL AND PROFITABLE FEEDING.

Now for the second question: What advantages for economical and profitable feeding are afforded?

Every intelligent feeder recognizes the necessity of having what is called a well-balanced ration; that he must mix the components of the feed according to the results that are desired. If feeding for milk and butter, there must be a certain ratio of carbohydrates to proteids, etc. There must be a different ratio when feeding for beef or for growth of young animals. The best results are obtained when a particular quantity of concentrates is mixed with a certain amount of roughage or hay.

It matters not how good a food a plant may make, it is not desirable unless it can be raised cheaply. For carbohydrates in the way of concentrates, the South has corn, oats, sorghum seeds, grass hay, etc., about the same as the North, and in addition the by-products of the rice mills and sugarhouses.

From observation and from available statistics the speaker believed that the land in the South will produce as much corn per acre as will the average land in any other portion of the United States.

It is true that there are some very poor, cotton-worn soils, but there are also vast quantities of territory that are extremely fertile. The cost of production is slightly greater than in the North and West, simply because improved agricultural implements have not come into extensive general use. Improved farm implements in the hands of intelligent white men will bring down the price of corn to what it is in the so-called corn States. But the South is not dependent on corn alone for highly concentrated carbohydrates.

Rice bran and rice polish, by-products from the rice mills, form excellent feed, comparing favorably with corn. A ton of rice bran contains approximately 240 pounds of protein. A ton of corn contains only 194 pounds, a difference of 25 per cent in favor of rice bran. On the other hand, corn contains 21 per cent more carbohydrates. Rice bran is quoted at $8.50 per ton. This would represent corn at about 25 cents per bushel. But as it is a by-product, its price will vary with the price of corn, for which it more nearly serves as a substitute.

PROTEIN CONCENTRATES.

Now, how is it with regard to the supply of protein concentrates? In the North wheat bran is the bountiful supply of highly protein feed. Cotton-seed meal takes its place in the South. Wheat bran contains about 15 per cent of protein and cotton-seed meal 42 per cent, or nearly three times as much as bran. When the enormous output of this product is considered it at once becomes evident that the South can furnish an abundant supply of the protein feed. It is highly esteemed for all animals except hogs, and large quantities are shipped North, where it is regarded as a valuable feed.

COTTON SEED.

The South produces about four and one-half million tons of cotton A good percentage is returned to the soils as raw-seed fertilizer.

A large part of the remainder has the oil extracted, and is then applied in the form of meal to the land whence it came, or to the land of some other farmer more thrifty and wise. A great deal is exported, and a comparatively small quantity is fed either as seed or meal on the farms where it is raised.

Science has done great service in revealing the value of this enormous product, but the South yet lacks one important step in following the teaching of science. This material should be fed to stock and the fertilizer should be saved and applied in the form of barnyard manure instead of applying it as raw material, provided its use can be supplemented by other things that can be grown to advantage.

FORAGE CROPS.

The speaker then began the discussion of forage crops. He said he had not claimed that the South had any material advantage in the production of concentrated feeds, but he believed it could stand on a par with any other section in this respect, while in the way of forage crops he would attempt to show that the climate gave it many advantages. Timothy, clover, red top, and oats are some of the best crops of the sections that raise the greater portion of high-bred animals. Timothy yields from 1 to 2 tons per acre, and one crop a year. The hay is poor in protein, containing less than corn in proportion to carbohydrates, and would therefore not be the best hay to combine with the cheaper starch feed stuffs. Clover yields slightly heavier crops, and is probably the best combination hay the South can raise. Its protein content is very high and is very desirable to combine with corn or other concentrates containing a high percentage of carbohydrates. Clover sometimes yields two cuttings a year, a hay crop and seed crop. The clover is the favorite hay and forage crop with many farmers, and if comparisons are made with the clover no one can justly object. Take the cowpea, the favorite of the South, and compare it with clover. It produces almost twice as much hay per acre. Cowpeas yield from 2 to 4 tons, while clover produces from 1 to 2 tons. A ton of clover contains about 206 pounds of protein and 760 pounds of nitrogen-free extract, and a ton of cowpea hay 332 pounds of protein and 844 pounds of nitrogen—a difference of 126 pounds protein and 84 pounds nitrogen in favor of the cowpea hay. It requires the use of the land for a year to produce a crop of clover and but from three to five months to mature a crop of cowpeas. In the South the farmer can easily raise a spring crop, plant cowpeas in June or July, and harvest a crop of fine hay in October. He then can sow oats, rye, barley, vetches, or crimson clover and have a winter pasture that will surpass anything that can be found in the North. This will of course require more labor and more expense, but the profits will come oftener.

Corn can be raised with cowpeas sown between the rows, and more hay can thus be raised than clover will produce when clover does its best. The corn and peas can be harvested, oats can be sown, harvested in the spring, more cowpeas sown and crop harvested before frost, making two crops each year.

Then, when we can raise more stuff to the acre, more crops in a given period of time, each richer in food value than the crops of the North, is it not very evident that we have very material advantages for stock raising? These crops will also make our soils richer, gathering nitrogen from the air and adding it to the soil.

The cowpea is not the only crop rich in protein that is raised in the South. It is simply the summer crop. Vetches and clovers are good winter crops and alfalfa is good for all the year. It furnishes from five to seven cuttings on the alluvial lands, and it probably does as well in the South as anywhere on the continent.

Lespedeza or Japan clover is well adapted for the poor hills, and produces as much hay as clover does on good soils in the North, but produces but one crop a year.

The speaker thought that he had shown that the South can obtain bountiful yields of highly nutritive forage, and that the production of these crops is less expensive than in the North on account of the increased number of crops and less capital required to get a given return.

PASTURING FACILITIES.

When pasturing facilities are compared, the advantage is still greater in favor of the South. While the Northern farmer is compelled to provide expensive houses to protect his animals from sleet, snow, and the cold northern winds, a simple shed affords ample winter protection in the South. There is also an ample supply of pure water.

There is practically no season of the year when there can not be a plenty of green forage, and while the cattle in the North are shivering in the cold and rooting in the snow for sprigs of winter grasses the Southern herds may be grazing on green winter pastures. In the North pasturing practically closes in November and opens May 1. Each year the pasture grass is very scarce, and during this time the animals are almost entirely dependent upon the harvested foods.

OVERPRODUCTION.

The question may be asked, that if this is all true why the farmers do not make use of their opportunity. The answer is that it has not been necessary. Until recently cotton, cane, and rice have been profitable, and the planter has been content to raise these money crops, which always find a quick cash sale anywhere. He has clung to them year after year hoping for better prices, losing year after year, and now he is financially unable to break away from the credit system and devote his farm to stock. But the time for large profits on cotton, cane, and rice has passed away; the cry of hard times is heard on every hand, and the low price of cotton is the topic discussed by every Southern planter. It is not a case of famine or crop failure, but overproduction.

The sooner the Southern farmer quits the one-crop system and resorts to diversified farming and stock raising the sooner he will begin to prosper. He should raise his own animals, feed them from his own fields, gather the manurial fertilizers and return them to further enrich the soil.

MARKET FOR SOUTHERN STOCK.

The question of a market for Southern stock will solve itself. When the conditions will justify it, packing houses will be established in the accessible Southern cities, and the embargo now placed on shipment to Northern markets will not cause trouble.

The speaker said he believed there is a profit to the small capitalist and money to be made by the large capitalist in raising cattle, hogs, horses, mules, and sheep in the Southern States.

THE WEATHER BUREAU AND THE FARMER.

RAIN FORECASTS.

Prof. Willis L. Moore, Chief of the Weather Bureau, said that while the greatest element of error in the work of the Bureau is in the making of rain forecasts, yet these predictions greatly benefit the agriculturist. Owing to the peculiar topography of California and its proximity to the ocean, and to the fact that storm conditions universally travel from the west, the Bureau is able to make rain predictions of great value to the farmers in that section. The value of the orange crop averages about $5,000,000 per annum; of the raisin crop about $3,000,000. Raisins are cured in the sun, and are subject to injury by rain if the workmen are not warned in time to stack the trays. Before the weather service was extended over California the loss to this crop from unexpected rains amounted to hundreds of thousands of dollars annually. Testimony from hundreds of owners of vineyards shows that practically not a pound of raisins has been damaged by rain during the past four years.

January 1, 1899, there were in the States of the Rocky Mountain slope 21,000,000 head of sheep and 13,000,000 head of cattle, exclusive of milch cows, horses, and mules. Cattle will live through all except the severest blizzards, but great loss is suffered by sheep owners unless they are able to protect their flocks.

COLD-WAVE WARNINGS.

The cold-wave warnings for these States have attained a much higher degree of accuracy in recent years. Even now an occasional cold wave will sweep over Montana, the Dakotas, Wyoming, and as far south as Colorado and Mexico without warning having been given. This is because cold waves always develop in the British Northwest possessions and cover the north Rocky Mountain plateau, and even reach a portion of our country before the reports from the Canadian stations can give us warning. A system is now in operation over the Rocky Mountain region which enables the Bureau to forewarn stockmen, though by a few hours only, of the coming blizzards.

An unusually cold wave swept over all the States from the Central Rocky Mountain plateau eastward to the Atlantic Ocean in January, 1887. According to estimates from shippers and others, the enormous sum of $3,504,000—three and one-half times the expense of maintaining the entire meteorological service of the Government for one year—was saved as the result of the Department's warnings.

RIVER AND FLOOD WARNINGS.

The speaker said his hearers of the Mississippi region are thoroughly familiar with the value of the river and flood warnings.

The floods of 1881 and 1882 caused a loss of not less than $15,000,000 to property in the Ohio and Mississippi valleys. The floods of 1882 caused a loss of 138 lives in the region from Cairo southward to New Orleans. The loss in the Ohio Valley alone by the flood of 1884 is variously estimated from $10,000,000 to $26,000,000.

During the great flood of 1897, its many stages were very accurately forecast a week in advance throughout practically the whole river system. The value of property saved by flood warnings during this flood in the Lower Mississippi Valley certainly amounted to many million dollars.

When the Mississippi River at New Orleans was at the highest stage ever known, warning was sent there that within five days there would be a rise of 1 foot. The rise came as predicted, but the levees had been strengthened and raised. Without the raise in the height of the levees the loss of life and property would have been unparalleled.

STORM WARNINGS.

The Bureau achieves its most signal success in its warnings of storms destructive to marine property and life. During the past four years not one of the twenty West Indian hurricanes which have swept our seaboard has visited a single port without the danger warnings preceding the storm, and as a result the loss of life and property has been infinitesimal in comparison with the destruction which ensued before the organization of the Department's meteorological service. Conservative marine insurance people estimate that each of these storms would leave from $2,000,000 to $3,000,000 worth of wreckage for them to settle for were it not for the advance information by the Weather Bureau.

EXTENSION OF METEOROLOGICAL SERVICE.

By direction of Secretary Wilson estimates were prepared for a complete meteorological service for the cotton fields of the South, similar to that in operation for the corn and wheat belt of the North, also for an extension of the service over the great arid and subarid regions of the West—a service similar to that which was in operation in the Mississippi Valley. Sixteen new stations were established.

When the war with Spain broke out action was promptly taken for the extension of the meteorological service over the region around the Caribbean Sea, and inside of sixty days a complete meteorological service was reporting twice daily from the principal islands of the West Indies and from the coast regions on the south and west, giving a daily service of atmospheric conditions so far unequaled in any other portion of the globe. The Bureau is thus enabled to detect the development of the most destructive storms that visit our continent, to measure them in their inception, to keep pace with them as they come up through the Caribbean Sea to the Gulf of Mexico, and to warn the commerce of all nations of the coming of the hurricanes.

STUDENT ASSISTANTS.

In accordance with directions of the Secretary some fifteen or twenty bright, deserving young men have been employed as student assistants at stations located in State universities, thus giving them what is equivalent to scholarships at these universities, and the Government has received an adequate return for its expenditure.

HOW WEATHER FORECASTS ARE MADE.

Describing how weather forecasts are made, he said:

> Twice daily observations are taken at all the stations in the United States at the same actual moment of time. These are collected by telegraph at the central office in Washington and other forecast centers. When lines are drawn indicating the stations having the same air pressure it is a simple matter to define the regions of high pressure and low pressure, or, in other words, the cool and clear regions, and the warm and moist regions. Weather conditions are dominated by what are called high-pressure and low-pressure areas. They are simply great eddies in the atmosphere drifting from the west toward the east, and controlling the sequence of our weather. Every cold wave is a marked high-pressure eddy, and every general rain storm is a marked low-pressure eddy. In the high-pressure eddy the air is drawn from above and forced outward in all directions from the center. In the low-pressure eddy the air from all directions is drawn inward toward the center and carried upward.
>
> Each meteorological chart shows the location of the highs and lows, their development and drift since the preceding report twelve hours before. It is from a comparison of the current chart with the preceding one that the forecaster makes his estimate of what will be the relative positions of the highs and lows during the coming thirty-six hours. Except the West Indian hurricanes, which visit our Atlantic ports in the fall of the year, all storms in this country move from the west.

The speaker closed with the statement that he believed it impossible to make a forecast based upon any principles of physics or upon any empiric rule in meteorology for a greater period than one or two days in winter or for more than two or three days in summer, and there are days in winter when the movement of air conditions is so rapid that it is extremely difficult to forecast even for a space of one day. "The Weather Bureau takes the public into its confidence in this matter, and does not claim to be able to do more than it is possible to accomplish."

FARMERS' BULLETINS.

The following is a list of the Farmers' Bulletins available for distribution, showing the number, title, and size in pages of each. Copies will be sent to any address on application to Senators, Representatives, and Delegates in Congress, or to the Secretary of Agriculture, Washington, D. C.: The missing numbers have been discontinued, being superseded by later bulletins.

16. Leguminous Plants. Pp. 24.
21. Barnyard Manure. Pp. 32.
22. The Feeding of Farm Animals. Pp. 32.
24. Hog Cholera and Swine Plague. Pp. 16.
25. Peanuts: Culture and Uses. Pp. 24.
27. Flax for Seed and Fiber. Pp. 16.
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56. Experiment Station Work—I. Pp. 31.
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58. The Soy Bean as a Forage Crop. Pp. 24.
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60. Methods of Curing Tobacco. Pp. 16.
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62. Marketing Farm Produce. Pp. 28.
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64. Ducks and Geese. Pp. 48.
65. Experiment Station Work—II. Pp. 32.
66. Meadows and Pastures. Pp. 28.
67. Forestry for Farmers. Pp. 48.
68. The Black Rot of the Cabbage. Pp. 22.
69. Experiment Station Work—III. Pp. 32.
70. Insect Enemies of the Grape. Pp. 23.
71. Essentials in Beef Production. Pp. 24.
72. Cattle Ranges of the Southwest. Pp. 32.
73. Experiment Station Work—IV. Pp. 32.
74. Milk as Food. Pp. 39.
75. The Grain Smuts. Pp. 20.
76. Tomato Growing. Pp. 30.
77. The Liming of Soils. Pp. 19.
78. Experiment Station Work—V. Pp. 32.
79. Experiment Station Work—VI. Pp. 28.
80. The Peach Twig-borer. Pp. 16.
81. Corn Culture in the South. Pp. 24.
82. The Culture of Tobacco. Pp. 24.
83. Tobacco Soils. Pp. 23.
84. Experiment Station Work—VII. Pp. 32.
85. Fish as Food. Pp. 30.
86. Thirty Poisonous Plants. Pp. 32.
87. Experiment Station Work—VIII. Pp. 32.
88. Alkali Lands. Pp. 23.
89. Cowpeas. Pp. 16.
91. Potato Diseases and Treatment. Pp. 12.
92. Experiment Station Work—IX. Pp. 30.
93. Sugar as Food. Pp. 27.
94. The Vegetable Garden. Pp. 24.
95. Good Roads for Farmers. Pp. 47.
96. Raising Sheep for Mutton. Pp. 48.
97. Experiment Station Work—X. Pp. 32.
98. Suggestions to Southern Farmers. Pp. 48.
99. Insect Enemies of Shade Trees. Pp. 30.
100. Hog Raising in the South. Pp. 40.
101. Millets. Pp. 28.
102. Southern Forage Plants. Pp. 48.
103. Experiment Station Work—XI. Pp. 32.
104. Notes on Frost. Pp. 24.
105. Experiment Station Work—XII. Pp. 32.
106. Breeds of Dairy Cattle. Pp. 48.
107. Experiment Station Work—XIII. Pp. 32.
108. Saltbushes. Pp. 20.
109. Farmers' Reading Courses. Pp. 20.
110. Rice Culture in the United States. Pp. 28.
111. Farmers' Interest in Good Seed. Pp. 24.
112. Bread and Bread Making. Pp. 39.
113. The Apple and How to Grow It. Pp. 32.
114. Experiment Station Work—XIV. Pp. 28.
115. Hop Culture in California. Pp. 27.
116. Irrigation in Fruit Growing. Pp. 48.
117. Sheep, Hogs, and Horses in the Northwest. Pp. 28.
118. Grape Growing in the South. Pp. 32.
119. Experiment Station Work—XV. Pp. 31.
120. Insects Affecting Tobacco. Pp. 32.
121. Beans, Peas, and other Legumes as Food. Pp. 32.
122. Experiment Station Work—XVI. Pp. 32.
123. Red Clover Seed: Information for Purchasers. Pp. 11.
124. Experiment Station Work—XVII. Pp. 32.
125. Protection of Food Products from Injurious Temperatures. Pp. 26.
126. Practical Suggestions for Farm Buildings. Pp. 48.
127. Important Insecticides. Pp. 42.
128. Eggs and Their Uses as Food. Pp. 32.
129. Sweet Potatoes. Pp. 40.
130. The Mexican Cotton Boll Weevil. Pp. 30.
131. Household Test for Detection of Oleomargarine and Renovated Butter. Pp. 11.
132. Insect Enemies of Growing Wheat. Pp. 40.
133. Experiment Station Work—XVIII. Pp. 32.
134. Tree Planting in Rural School Grounds. Pp. 38.
135. Sorghum Sirup Manufacture. Pp. 40.
136. Earth Roads. Pp. 24.
137. The Angora Goat. Pp. 48.
138. Irrigation in Field and Garden. Pp. 40.
139. Emmer: A Grain for the Semiarid Regions. Pp. 16.
140. Pineapple Growing. Pp. 48.
141. Poultry Raising on the Farm. Pp. 16.
142. The Nutritive and Economic Value of Food. Pp. 48.
143. The Conformation of Beef and Dairy Cattle. Pp. 44.
144. Experiment Station Work—XIX. Pp. 32.
145. Carbon Bisulphid as an Insecticide. Pp. 28.
146. Insecticides and Fungicides. Pp. 16,
147. Winter Forage Crops for the South. Pp. 36.
148. Celery Culture. Pp. 32.
149. Experiment Station Work—XX.
150. Clearing New Land.

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U. S. DEPARTMENT OF AGRICULTURE.

FARMERS' BULLETIN No. 99.

THREE INSECT ENEMIES OF SHADE TREES.

BY

L. O. HOWARD,
ENTOMOLOGIST.

[Reprinted, with some annotations by the author, from the Yearbook of the Department of Agriculture for 1895.]

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1899.

LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Division of Entomology,
Washington, D. C., May 26, 1899.

Sir: I have the honor to transmit herewith a copy of an article contributed by me to the Yearbook for 1895, entitled "The shade-tree insect problem in the Eastern United States." I have found the reprints of this article of great use in correspondence, and as the edition is exhausted, I recommend that it be republished, under the title Three Insect Enemies of Shade Trees, as a Farmers' Bulletin. I have in preparation a more extended bulletin on the subject of shade-tree insects, but in the interval which will elapse before it is completed the Farmers' Bulletin reprint of the Yearbook article will be of service.

Respectfully,

L. O. Howard,
Entomologist.

Hon. James Wilson,
Secretary of Agriculture.

CONTENTS.

Page.
The imported elm leaf-beetle 7
    Original home and present distribution 7
    Food plants 8
    Life history 8
    Remedies 10
The white-marked tussock moth 12
    Original home and present distribution 12
    Food plants 12
    Life history and habits 12
    Remedies 17
The fall webworm 20
    Remedies 20
The relative immunity from insects of different varieties of shade trees 21
General work against shade-tree insects in cities and towns 25

ILLUSTRATIONS.

Page.

FIG. 1.—Bagworm (*Thyridopteryx ephemeræformis*) 5

2.—Bagworm; successive stages of growth 6

3.—The imported elm leaf-beetle (*Galerucella luteola*) 9

4.—White-marked tussock moth (*Orgyia leucostigma*)..................... 13

5.—Tussock-moth caterpillar, first three stages........................... 14

6.—Tussock-moth caterpillar, last stages................................ 15

7.—Silver maple leaves eaten by larvæ of white-marked tussock moth in successive stages 18

8.—Ichneumonid parasites of tussock-moth caterpillar 19

9.—Fall webworm (*Hyphantria cunea*), moths and cocoons............... 24

10.—Fall webworm, forms of larva and pupa............................ 26

11.—Fall webworm, larva and web...................................... 27

THREE INSECT ENEMIES OF SHADE TREES.

The space at command will not admit of a full treatment of the problem outlined in the [original] title of this article, and the writer has therefore brought together at this time some account of three species which are perhaps the most destructive among shade-tree insects, or which, at all events, have attracted the greatest attention during the past season. To this he has added a brief consideration of the relative immunity of shade trees from insect attack, and some remarks on the subject of general work against shade-tree insects in cities and towns.

One of the most striking features of the summer of 1895 has been the great abundance in many Eastern cities of several species of insects which attack shade trees. In almost every low-lying town from Charlotte, N. C., north to Albany, N. Y., the elm leaf-beetle has defoliated the English elms and, in many cases, the American elms. In certain directions this insect has also extended its northern range, notably up the Connecticut River Valley. The authorities in a number of Eastern cities have taken the alarm, and active remedial work will be instituted during the coming season. In cities south of New York the bagworm has been gradually increasing for a number of years until it has become a serious enemy to shade and ornamental trees for almost the first time since 1879 or 1880 (figs. 1 and 2). The white-marked tussock moth, the caterpillar of which has been for many years the most serious of the shade-tree pests in Philadelphia, New York, Brooklyn, and Boston, in 1895, for the first time within the recollection of the writer,

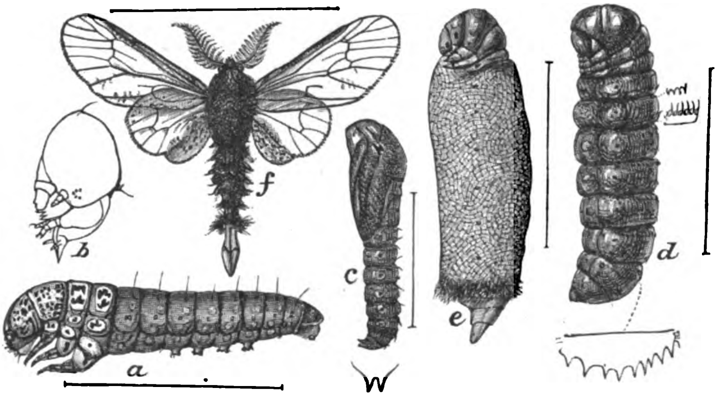

FIG. 1.—Bagworm (*Thyridopteryx ephemeræformis*). *a*, larva; *b*, head of same; *c*, male pupa; *d*, female pupa; *e*, adult female; *f*, adult male—all enlarged (original).

appeared in such numbers as to become of great importance in more southern cities, as Baltimore and Washington. The fall webworm (figs. 9, 10, and 11) was more abundant in Washington and the surrounding country than it has been since the summer of 1886.

These four insects are the principal shade-tree defoliators in the Eastern States, if we except the imported gypsy moth, which is at present fortunately confined to the immediate vicinity of Boston, and is being cared for by a thoroughly capable State commission. While the summer of 1895 may with justice be called an exceptional one as regards the great increase of numbers, yet these insects are always present and do a certain amount of damage each season, and, when an exceptional season comes, as it did in 1895, city authorities seldom find themselves prepared to engage in an intelligent and comprehensive fight.

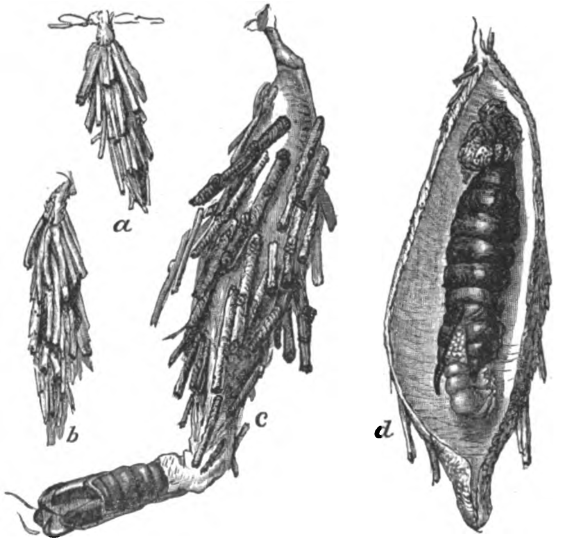

FIG. 2.—Bagworm at (*a*, *b*, *c*) successive stages of growth. *c*, male bag; *d*, female bag—natural size (original).

In cities farther west other leaf-feeders take the place of those just mentioned. The principal ones are, perhaps, the oak Edema, the cottonwood leaf-beetle, and the green-striped maple worm.

Several scale insects or bark lice are occasionally serious enemies to shade trees. Maples suffer especially from their attacks. The cottony maple scale is found everywhere on all varieties of maple, and occasionally in excessive abundance. The cottony maple leaf scale, a species imported from Europe, is rapidly gaining in importance, and in several New England towns it has, during the past season, seriously reduced the vitality of many trees. The so-called "gloomy scale" has long been on the increase in Washington, D. C., and every year it kills large branches and even entire trees of the silver maples, which are so extensively grown along the streets of that city.

Certain borers are also occasionally destructive to many shade trees, and, in fact, in the northern tier of States these are the most important of the shade-tree enemies, the principal leaf feeders being either absent or becoming single brooded. Where absent their places are taken by less destructive species.

In fact, it is safe to say that shade trees suffer especially from insect attack throughout the region of country which is contained in the Upper Austral life zone.[1]

Concerning the borers, it may be briefly said that these insects rarely attack vigorous and healthy trees, but should a shade tree lose its health through the attacks of scale insects, through rapid defoliation by leaf feeders, or through a leaky gas main or sewer pipe, different species of borers will at once attack and destroy it. There is one particular exception to this rule, and that is the European leopard moth, a most destructive species, which is at present of very limited range and confined to the immediate vicinity of New York City. No certain information is at hand which indicates that it has spread for more than 50 miles from the center of introduction. This insect attacks healthy trees, boring into the trunks of the younger ones and into the branches and smaller limbs of many shade and fruit trees. It is an extremely difficult species to fight, and it is fortunate that its spread is not more rapid.

THE IMPORTED ELM LEAF-BEETLE.

(*Galerucella luteola* Müll.)

Original home and present distribution.—The imported elm leaf-beetle (fig. 3) is a native of southern Europe and the Mediterranean islands. It is abundant and destructive in the southern parts of France and Germany, and in Italy and Austria. This beetle is found, though rarely, in England, Sweden, and north Germany, and gradually becomes less numerous and destructive toward the north. In middle Germany it is common, though not especially destructive. As early as 1837 it was imported into the United States at Baltimore, and is now found as far south as Charlotte, N. C. From this point it ranges northward in the Atlantic cities as far as Providence, R. I. Inland it has not passed the barrier of the Appalachian chain of mountains, and is practically confined to the Upper Austral region, as indicated in the map on page 210 of the Yearbook for 1894. Thus, up the Hudson River it has spread to Albany, N. Y., but on either side of the river, as the land rises into the foothills, it has stopped. In the same way it has more recently spread up the Connecticut River Valley to a point north of the New Hampshire State line, and also, to a less extent, up the Housatonic Valley. From our present knowledge it seems likely that its future spread as an especially destructive species will be limited by the northern border of the Upper Austral region, and that (as may happen at any time) should it once be carried by railway train across the southern extension of the Transition life zone, caused by the Allegheny and Blue Ridge mountains, it will spread unchecked through Ohio, Indiana, Kentucky, Tennessee, and other Western States.[1]

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[1] Briefly defined by Dr. Merriam in his summary article on "The geographic distribution of animals and plants in North America," in the Yearbook of this Department for 1894, page 203.

Food plants.—No food plants other than elms are known. The common English elm (*Ulmus campestris*) is its favorite food, and the gardener's variety, the so-called Camperdown, or weeping elm, is attacked with equal avidity. The American, or white, elm (*U. americana*) ranks next among the favored species, with *U. montana*, *U. suberosa*, *U. flava*, *U. racemosa*, and *U. alata* in about the order named. No variety seems absolutely exempt. In the presence of *U. campestris* other elms are seldom seriously injured. Where *campestris* is absent, or where a single tree of *campestris* is surrounded by many American elms, the latter become seriously attacked.[2]

Life history and habits.—The elm leaf-beetle passes the winter in the adult, or beetle, condition in cracks in fences or telegraph poles, under the loose bark of trees, inside window blinds in unoccupied houses, in barns, and, in fact, wherever it can secure shelter. As soon as the buds of the trees begin to swell in the spring, the beetles issue from their winter quarters and mate, and as soon as the buds burst they begin to feed upon the leaflets.

This feeding is continued by the beetles until the leaves are fairly well grown, and during the latter part of this feeding period the females are engaged in laying their eggs. The eggs (fig. 3, *c*) are placed on the lower sides of the leaves, in vertical clusters of 5 to 20 or more, arranged in two or three irregular rows. They are elongate oval in shape, tapering to a rather obtuse point, orange yellow in color, and the surface is covered with beautiful hexagonal reticulations. These reticulations, however, can be seen only with a high magnifying power.

The egg state lasts about a week. The larvæ (fig. 3, *d*) as soon as hatched feed on the under surface of the leaf, gradually skeletonizing it. They reach full growth in from fifteen to twenty days, and then either crawl down the trunk of the tree to the surface of the ground or drop from the extremities of overhanging branches. At the surface of the ground they transform to naked, light orange-colored pupæ (fig. 3, *g*), a little over a quarter of an inch in length, and in this stage they remain for from six to ten days, at the expiration of that time transforming to beetles. The pupæ will frequently be found collected in masses at the surface of the ground in this way. On very large trees with shaggy bark many larvæ will transform to pupæ under the bark scales, or on trees of the largest size they may descend the main

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[1] Since this was written the writer has learned that this passage of the Blue Ridge barrier has actually taken place during the past season. Mr. A. D. Hopkins, of the West Virginia Agricultural Experiment Station, has found that this insect has established itself at Elmgrove, in Ohio County, and at Wellsburg, in Brooke County, W. Va.

[2] The beetles rarely oviposit upon *Zelcova carpiniafolia* and *Z. acuminata* on the Department grounds at Washington.

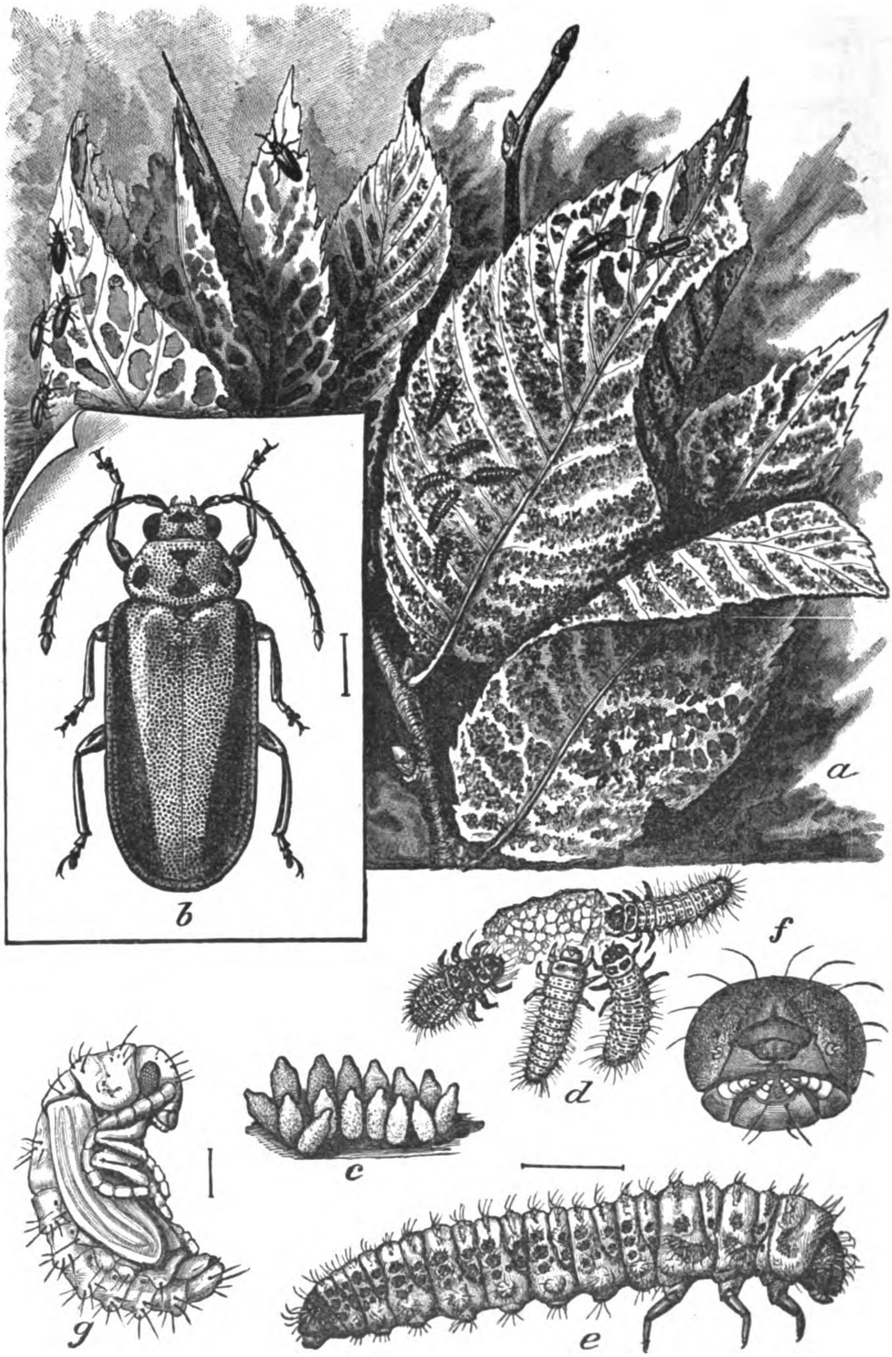

FIG. 3.—The imported elm leaf-beetle (*Galerucella luteola*). *a*, foliage of European elm showing method of work of beetle and larva—natural size; *b*, adult beetle; *c*, egg mass; *d*, young larvæ; *e*, full-grown larva; *g*, pupa—all greatly enlarged; *f*, mouth parts of full-grown larva—still more enlarged (original).

branches to the crotch and transform unprotected in the hollow of the crotch.

The larva is elongate, reaching when full grown (fig. 3, *e*) half an inch in length. When first hatched it is nearly black; as it increases in size it becomes, with each shedding of the skin, more distinctly marked with yellow, and when mature the yellow predominates, occurring as a broad dorsal stripe and two lateral stripes.

The difference between the early work of the beetles and the later work of the larvæ is recognized at a glance. The beetles eat entirely through the leaves and make complete, irregular holes, while the larvæ simply eat the parenchyma from below, skeletonizing the leaf.

The time occupied in egg laying is long, and it thus happens that at the time when full-grown larvæ, and even pupæ, are to be found there are also upon the leaves freshly laid eggs.

In Washington there are invariably two generations annually, the beetles developed from the eggs laid by the overwintered beetles themselves laying their eggs in July. The adults issuing from these eggs make their appearance in August. Farther north, at New Brunswick, N. J., and in the Connecticut cities, it may be said that there is normally a complete first generation and an incomplete second generation.

The proper food of the larvæ is the rather young and tender leaves. If the work of the first generation has not been complete, and the trees have not been so nearly defoliated as to necessitate the sending out of fresh leaves, or if a period of drought ensues after defoliation and prevents the putting out of a second crop of leaves, the beetles of the first generation do not lay eggs, but after flying about for a time seek winter quarters. This may occur as early as the middle of July. Where, however, defoliation has been complete and has been followed by a period of sufficient moisture to enable a tree to put out a fresh crop of leaves, the beetles of the first generation will lay their eggs and a second generation of larvæ will develop upon this comparatively tender foliage. Where similar conditions prevail in Washington and its vicinity, a third generation of larvæ may develop, though small in numbers, but the writer is convinced that even in Washington late-developing beetles of the first generation may hibernate.

Remedies.—The only thoroughly satisfactory safeguard against this insect consists in spraying the trees with an arsenical solution. The only other remedy which is worthy of mention is the destruction of the larvæ at the surface of the ground before or after they transform to pupæ. The latter remedy, however, is not complete, and even where it is carefully carried out for every tree in a city it will do no more than reduce the numbers of the insects by perhaps two-thirds.

Ten years ago a proposal to spray the enormous elms which are to be found in many Northern towns would have been received with ridicule, but of recent years the practicability of the plan has so frequently been demonstrated that there is no hesitancy in commending it to more general city use. Probably the largest elm tree in America, the Dexter elm at Medford, Mass., has been successfully and economically sprayed by the Gypsy Moth Commission. It is necessary to have especial apparatus constructed, and it is equally necessary to have the work done by men who are accustomed to it or at least are good climbers. The first successful work of this kind was probably that done by Prof. John B. Smith, on the campus of Rutgers College. He had a strong barrel pump, and carried the nozzle at the end of a long rubber tube, with a bamboo extension pole, up into the center of the trees by climbing a ladder to the main crotch. From this point the spray was thrown in all directions, and the tree was thoroughly coated with the mixture in a minimum of time.

The Gypsy Moth Commission, in their earlier spraying work, sent their large tank carts through the streets, stopping at each tree and sending one or more men with hose and extension poles into it, thus covering hundreds of large trees in a single day. If steam sprayers are used (and the town or city fire engines can be and have been used to excellent advantage in this way), the necessity for climbing the trees may be largely avoided. By means of multiple-discharge hose both sides of a tree, or even of two trees, may be sprayed at once, and the extent of territory that may be covered in a day is surprising. The elm trees in a small park may be treated economically and without much difficulty by two or three men with a handcart tank. This method has been adopted on the large grounds of the Department of Agriculture with absolute success.

The writer's experience at Washington leads to the conclusion that it is important to spray trees once just after the buds have burst. This spraying is directed against the overwintered beetles. If a large proportion of these beetles can be destroyed by poisoning the leaves which they eat, not only will a great deal of leaf perforation by the beetles themselves be prevented, but the number of eggs laid will be very greatly lessened. A second spraying should be conducted two weeks later. This is directed against the larvæ, the majority of which will perhaps have hatched by that time or soon after. A third spraying, and even a fourth, or under exceptional circumstances a fifth, may be required if it is considered necessary to keep the trees fresh and green, and particularly if the earlier sprayings have been followed by rains, as is apt to be the case in the earlier part of the season. In Bridgeport, Conn., where only a part of the trees are sprayed and these by private enterprise, an even greater number of operations have been found desirable. Three thorough sprayings of all the trees in a given precinct will probably be as much as will be required, especially if this be done year after year and some pains be taken to destroy such of the larvæ as may successfully develop and descend for transformation. Even two sprayings, covering all the elms of a city or town, will be well worth the expense.

The substance to be used in these spraying operations may be Paris green, London purple, or arsenate of lead. The directions for the use of these substances have been so often repeated, that it is not worth while to mention them here.

The other remedy—the destruction of the descending larvæ and the quiescent pupæ—is, as above stated, and must always be, incomplete. The standard kerosene emulsion, diluted one part to five parts of water, will destroy the insects in either of these stages. This has been successfully used in several New England towns the past season, particularly in New Haven. It must be applied to the base of the trunk and under the entire limb spread of the tree. The rough bark must be removed to a slight extent (the writer does not advocate severe scraping), leaving as few crevices as possible which may harbor the pupating insects. If a tree is very large, it will pay occasionally to climb into the main crotch and destroy such individuals as may have collected at that point. Experience leads us to the estimate that on large trees not more than one-half to two-thirds of the larvæ reach the base of the trunk and transform at that point. The extent to which larvæ drop from overhanging branches has been questioned, and it is sometimes a difficult matter to decide. The city forester of Springfield, Mass., however, called our attention to a peculiar and eminently satisfactory case where the drooping branches of a large elm extended completely over a house on the other side of which there were no elm trees. On the far side of the house, beneath the tips of the overhanging branches, the larvæ and pupæ were collected in large numbers in the summer of 1895.

THE WHITE-MARKED TUSSOCK MOTH.

(*Orgyia leucostigma* Smith and Abbot.)

Original home and present distribution.—This insect is a native of North America. It ranges from Jacksonville, Fla., to Nova Scotia, on the eastern coast, and extends west certainly as far as Keokuk, Iowa, and probably farther, although the records at command include no actual captures beyond this point.[1] It does not occur in California, so far as learned.

Food plants.—It attacks almost every variety of shade, fruit, and ornamental trees, with the exception of the conifers. In the city of Washington it seems to select by preference the poplars, soft maples, the elms, alders, and birches, as well as the willows. It is also found here on apple, pear, cherry, plum, peach, other varieties of maple, locust, box elder, ash, catalpa, rose, horse-chestnut, persimmon, sycamore, mulberry, and a number of other trees.

Life history and habits.—This insect passes the winter in the egg state. The overwintering eggs are laid by the female moth in the latter part of September, in a glistening white, frothy-looking mass attached to the outside of the cocoon. They are seen at a glance, owing to their pure white color, and remain conspicuous upon the trees until spring. The caterpillars hatch in Washington in April and May. They are represented at different stages of growth in figs. 4, 5, and 6, and in view of the care with which these figures have been drawn detailed descriptions will be unnecessary. They cast the skin five times, exhibiting a different character after each molt, as indicated in the figures. The newly hatched young feed on the under surface of the leaf, eating off the parenchyma and producing a skeletonized appearance. After the first molt the skeletonizing continues, but a few holes are eaten completely through the leaf; after the second molt many holes are eaten through between the main ribs, and after the third molt the leaf is devoured, except for the midrib and its principal branches. After the fourth molt the caterpillars begin to eat from the edge of the leaf and devour everything except the principal veins.

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[1] Prof. L. Bruner has since reported this species from Omaha and Lincoln, Nebr.

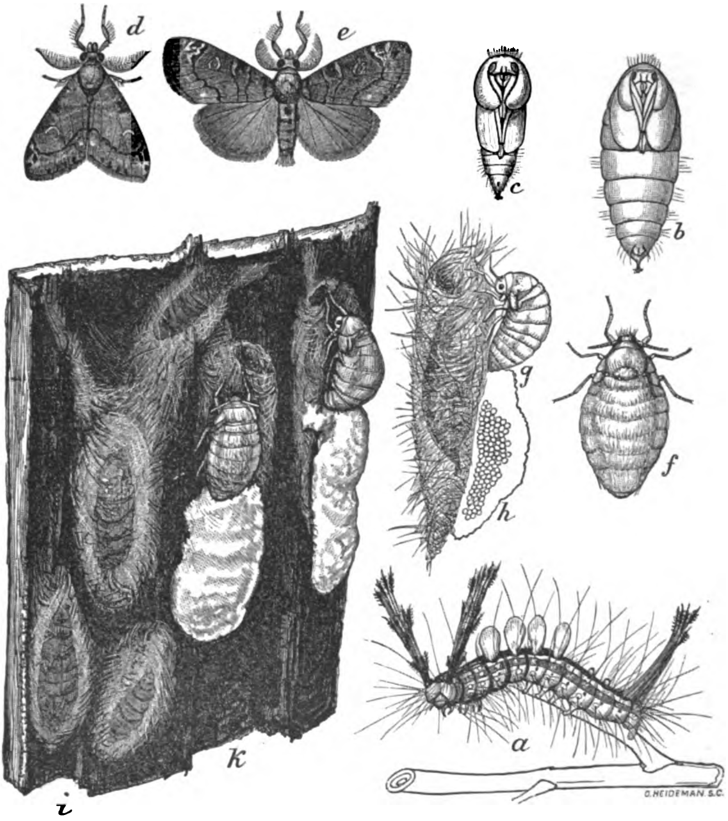

FIG. 4.—*Orgyia leucostigma.* *a*, larva; *b*, female pupa; *c*, male pupa; *d*, *e*, male moth; *f*, female moth; *g*, same ovipositing; *h*, egg mass; *i*, male cocoons; *k*, female cocoons, with moths carrying eggs—all slightly enlarged (original).

Similar work is done in the last stage upon the full-grown and tough leaves (see fig. 7).

A most peculiar kind of damage by the caterpillars of this species has been observed by Dr. Lintner in Albany, N. Y. There, in the summer of 1883, he found that the tips of many twigs were girdled by the caterpillars, which had entirely removed the bark for a tenth of an inch. Such twigs broke off and fell to the ground, with their leaves. This damage was so common in 1883 that the sidewalks of the streets and public parks wherever the American elm was growing were sprinkled with the newly fallen leaves. Dr. Lintner was of the opinion that a cold spring and the sudden advent of warm weather caused an unusually vigorous growth of the terminal twigs, and that the young tips were therefore unusually tender. They thus proved appetizing to the tussock-moth caterpillars, which developed a new habit for the occasion. This peculiar damage was repeated in 1895, but to a less extent. No other observer in any part of the country has ever reported similar damage.

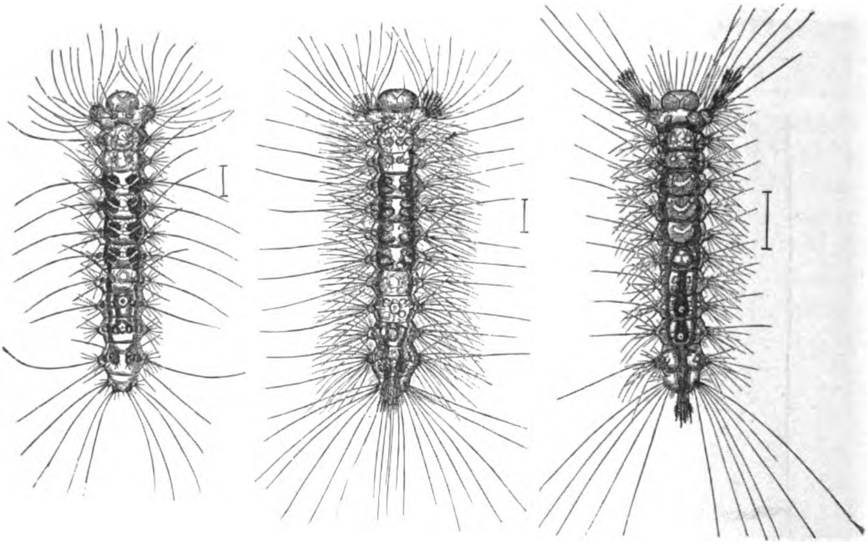

FIG. 5.—Tussock-moth caterpillar. First, second, and third stages—enlarged (original).

The young caterpillars drop down, suspended by silken threads, at even a slight jarring of the tree, and frequently spin down without such disturbance, and are blown to a considerable distance by the wind. When nearly full grown they are great travelers, crawling down the trunk of the tree upon which they were hatched and across a considerable stretch of ground, to ascend another tree. When they occur in numbers, an extensive migration will always take place from a tree which has been nearly defoliated, and the species spreads mainly, if not entirely, in this way. Just as is the case with the gypsy moth, the caterpillars are carried by vehicles upon which they crawl or drop, or upon the clothes of passers-by, and in this way many trees upon which there were no egg masses become infested.

The larval state lasts, on an average, from a month to five weeks. When full grown, the larvæ spin delicate grayish cocoons of silk mixed plentifully with hairs. The mixture of hair is brought about by the fact that the hairs are barbed and rather loosely attached to the body. When a caterpillar begins to spin its cocoon the hairs of its body and those of the long, black tufts on the prothorax first become entangled with the silken threads and are pulled out. By the time the cocoon has begun to take shape, the characteristic long, black tufts of hair have entirely disappeared from the body of the caterpillar. Later the shorter hairs of the sides of the body become entangled and removed, and finally many of the hairs composing the brush-like tufts upon the fore part of the body are pulled out, and just before it transforms to pupa the caterpillar bears but a remote resemblance to the individual before it began to spin.

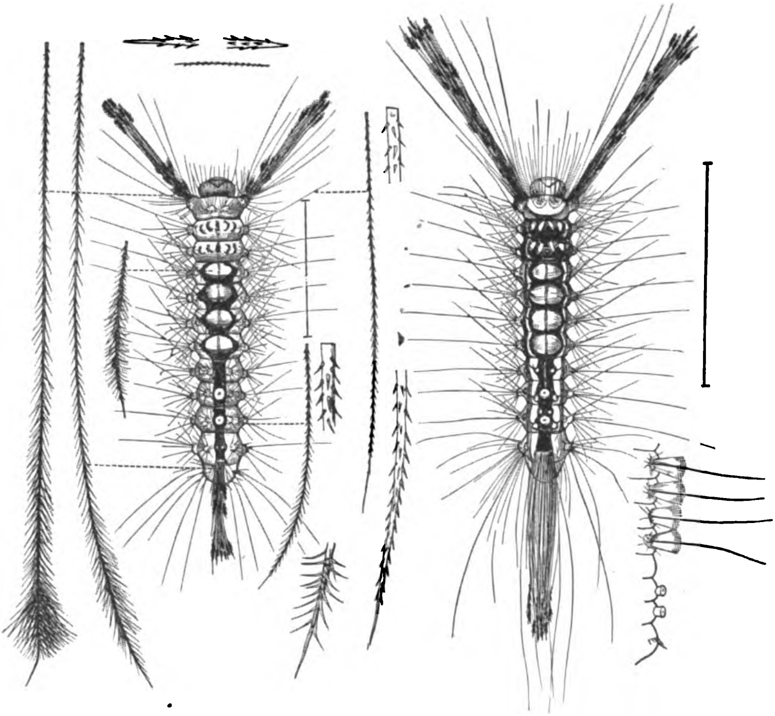

FIG. 6.—Tussock-moth caterpillar. Third and fourth stages, showing enlarged hairs from different parts of body (original).

The barbed hairs just mentioned may occasionally produce considerable irritation of the skin of people upon whom the caterpillars may have crawled or dropped from the trees. The hairs from the different portions of the body of the full-grown caterpillar are illustrated, greatly enlarged, in fig. 6, and it is the shorter hairs from the sides which probably cause the irritation. They are very small, fall out readily, and, when a caterpillar crawls over the skin of an individual who is warm and perspiring, these very sharply barbed hairs produce an irritation which in some individuals has been the cause of much discomfort, creating more or less inflammation and swelling.

The larva transforms to pupa within a few hours after the completion of the cocoon, and remains in the pupal condition from ten days to two weeks. The cocoons of this first generation, while mainly spun on the trunk and larger branches, are also spun to a very considerable extent upon the smaller branches and twigs, and even on the partly eaten leaves.

The adult insect presents the rather unusual phenomenon of a winged, active male and a degraded, absolutely wingless female. It is this fact which makes the spread of the species dependent upon the traveling powers of the caterpillar, as mentioned in the preceding paragraph. The male and female pupæ and the male and female moths are so well shown in fig. 4 as to need no description.

Coupling takes place upon issuing from the cocoon, and immediately afterwards the females begin to lay their eggs, clinging firmly to the cocoons from which they have issued and attaching the egg mass to the lower half of the cocoon, in the manner shown in fig. 4, *h* and *k*. As soon as the eggs are laid the females die, and usually fall to the ground, although sometimes their shriveled bodies remain clinging by the legs to the upper part of the cocoon.

We have made no observations as to the duration of these midsummer eggs. Unfortunately, upon the length of time which elapses before hatching depends exact information as to the number of annual generations. Specific observations in 1895 in Washington were not begun until August 15. At that time the egg masses were everywhere to be seen, and about that time the eggs began to hatch. From the early statements of Riley it was assumed that these were the eggs of the second generation, but reference to the notebooks of the office shows that on several occasions overwintered eggs have hatched in Washington in April, and adults have issued as early as the middle of June. From the middle of June to the middle of August is certainly long enough to allow for a generation of this insect. Assuming that such a generation had developed, larvæ from these August eggs would belong to the third generation.[1] This, however, is to a certain extent guesswork, and the regrettable lapse of observations during the last half of

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[1] Observations made during 1896 confirmed fully the surmise here recorded that the white-marked tussock moth has at Washington three generations annually, instead of two, as previously stated by Riley. (See Bulletin 10, Division of Entomology, p. 33.)

June, the whole of July, and the first half of August could be remedied only in another season.

Elaborate observations were made upon this August brood in 1895, the individuals of which were present in extraordinary numbers. Certain of the larvæ under observation, which hatched on August 2, commenced to spin upon September 3, and on September 14 the first male moths made their appearance, the first females issuing September 19. During the latter part of September the bulk of the moths issued, and the conspicuous white egg masses were very abundant by the 1st of October. Many of these egg masses were kept under observation from that time on. In the cold room of the insectary (temperature the same as outdoors) a few eggs hatched about the close of the second week in October, and on October 23 two newly hatched larvæ were observed upon an egg mass collected out of doors. This late fall hatching, however, is probably exceptional, but in a late, warm autumn it is likely to be rather general. It is hardly to be supposed that any individuals hatching after the 1st of October will successfully transform. The cocoons of this late fall generation are almost invariably spun upon the trunk of the tree and in the crotches of the main limbs, but occasionally, in the case of large trees, upon the larger limbs themselves. The tendency of all the larvæ of this generation is to crawl toward the ground before transforming. Cocoons are occasionally spun upon fences or other objects near the trees upon which the larvæ have been reared, but the vast majority are found upon the trunks.

There are, then, certainly two, and probably three, annual generations at Washington.[1] In New York and Brooklyn there are two well-marked generations. At Boston, as is learned from Mr. Samuel Henshaw, there are two generations. Farther north, however, although the statement is based upon no exact observation, it is not at all likely that there are more than one, and, as stated in the introduction, the comparative harmlessness of the species in such regions is probably due to the nondevelopment of the second generation.

Remedies.—There are two classes of remedies as well as an excellent preventive that may be used to advantage against this insect. These are the collection or destruction of the eggs in the winter, spraying the trees against the larvæ, and banding unattacked trees to prevent the ascent of the caterpillars and the subsequent development of moths and the laying of eggs.

The collection and destruction, or the destruction without collecting, of the eggs must be thorough in order to have any practical efficacy. The great majority of the hibernating egg masses are deposited low down on the trunk of the tree or upon the main limbs, so that they can be reached in one way or another without much difficulty. The egg mass is compact, and, being attached to the somewhat flimsy cocoon and not to the bark, it is easily removed either by hand or by scraping it off. The egg masses which have been scraped off must not be allowed to remain at the surface of the ground, but should be collected and burned. A scraper for the removal of egg masses which occur too high to be reached by hand has been devised by Mr. Southwick, of Central Park, New York City, and consists of a very small hoe blade at the end of a long pole. Perfectly unskilled labor can be utilized in this operation, but the workman should be impressed with the necessity of absolute thoroughness; not an egg mass should be overlooked.

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[1] Certainly occasionally, and probably always, three, as indicated in the footnote on the preceding page.

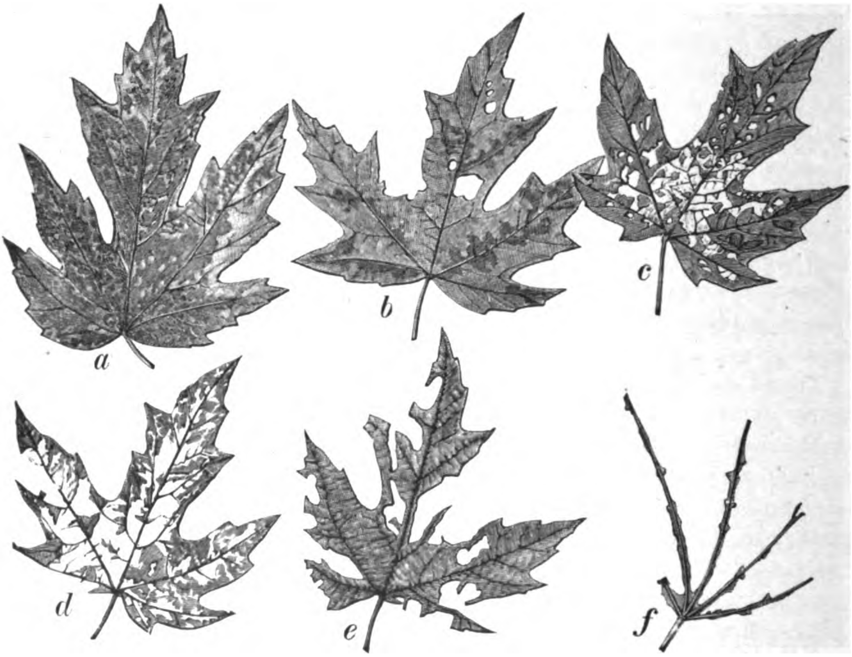

FIG. 7.—Silver maple leaves eaten by larvæ of white-marked tussock moth in successive stages of growth from *a* (newly hatched larvæ) to *f* (full-grown larvæ)—reduced (original).

In the work against the gypsy moth in Massachusetts it has been found that the egg masses can not be removed to the best advantage by means of scrapers. The eggs are attached, not to the cocoons, but to the bark of the trees, and certain eggs may be left in the attempt to remove the mass. An extensive series of experiments has therefore been carried on with a view to securing a liquid which will penetrate and destroy the egg masses.

A satisfactory liquid for this purpose has been found in creosote oil, to which turpentine is added to keep it liquid in cold weather, with tar to blacken it so that treated egg masses can be recognized at a glance.

The workman is furnished with a pole, to the end of which a small sponge is tied. He goes from tree to tree, dipping the sponge occasionally into the creosote preparation and touching with it each egg mass found. This is a simple and very rapid method. It has the advantage of rapidity over the scraping method described above, since after the eggs are scraped off they must be collected and carried away for burning.

A modification of this plan may be used to advantage against the tussock moth. The pure white color of the egg mass of the tussock moth, however, renders the use of coal tar in the preparation unnecessary, since the creosote oil alone will discolor it enough to render a treated mass recognizable at a distance.

No explicit directions for spraying with arsenical poisons against this insect are needed. The same liquid and the same apparatus that are used against the elm leaf-beetle may be used against this insect, and the spraying may be done at about the same time of the year. It is essential that the caterpillars of the first generation shall be killed, as the second and more destructive brood will thus be prevented.

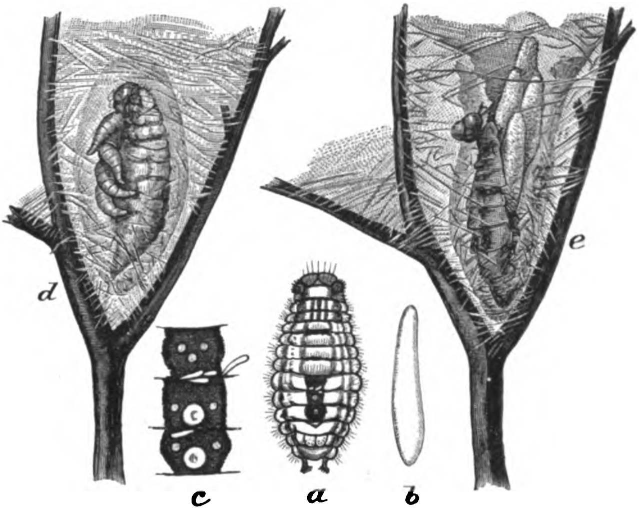

FIG. 8.—*Pimpla inquisitor*, an Ichneumonid parasite of tussock-moth caterpillar. *a*, parasitized caterpillar; *b*, egg of parasite; *c*, same *in situ*; *d*, parasite larvæ issuing; *e*, parasite cocoons—all slightly enlarged, except *b* and *c*, which are much enlarged (original).[1]

Banding of the trees is practiced to advantage with this species. It is the only one of the shade-tree insects, except the bagworm, which has a wingless female. All the others, except the gypsy moth, spread from tree to tree by the flight of the female. Many experiments have been made with different styles of bands, and it has been practically proved that a broad, thick strip of raw cotton, tied about the trunk of the tree with a string, is after all the most efficacious and perhaps the cheapest. Such bands have to be renewed occasionally, as they become more or less matted together and spoiled by rainstorms.

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[1] See Bulletin 5, technical series, Division of Entomology, and Bulletin 9, new series, pages 15–17, for an extended account of the parasites of this species. The injurious outbreak of 1895 was checked in the most perfect manner by these parasites, so that the tussock moth was hardly to be noticed during the latter part of 1896, or during 1897 or 1898.

Next in point of efficacy will probably come bands of insect lime, several brands of which are on the market. Insect lime is a sticky, coal-tar product, which retains its viscidity for a considerable time. A ring made around a tree will remain operative for some weeks in warm weather.

THE FALL WEBWORM.

(*Hyphantria cunea* Drury; figs. 9 to 11.)

Associated with the white-marked tussock moth in its damage to the shade trees of the city of Washington during the summer of 1895, were very many specimens of the fall webworm; in fact, this insect was more abundant during the summer of 1895 than it has been in Washington since 1886. It was not as numerous and destructive as the white-marked tussock moth, and the last generation was so extensively parasitized as to lead to the anticipation that the species would not be especially abundant during 1896.

The fall webworm is a typical American species. It is found from Canada to Georgia and from Montana to Texas. It is an almost universal feeder, and the records of the Division of Entomology list about 120 species of shade and ornamental trees, as well as fruit trees, upon the leaves of which it feeds.

In the District of Columbia and north to New York City there are two generations annually, as is the case with the tussock moth. In more northern localities, where it is single-brooded, it loses its place as a species of great importance. It hibernates as a pupa within a cocoon attached to the trunk of its food plant, or to tree boxes, neighboring fences, or to rubbish and sticks or stones at the surface of the ground. The different stages of the insect are shown in figs. 9 to 11. The moth, which may be either pure white or white spotted with black, flies at night and deposits a cluster of 400 or 500 eggs, upon either the upper or the under surface of the leaf. The caterpillars feed gregariously, and each colony spins a web which may eventually include all the leaves of a good-sized limb. Reaching full growth, the caterpillars leave the web and crawl down the trunk of the tree to spin their cocoons. The caterpillars of the second generation begin to make their appearance in force in August.

Remedies.—On account of the fact that the adult female is an active flier, we can use against the fall webworm but two of the remedies suggested for use against the tussock-moth caterpillars, namely, spraying with arsenical poisons and the collection of the cocoons. The gregarious habit of the larvæ, however, suggests another remedy which is practical and very efficient if thoroughly carried out. This is the destruction of the webs and the contained larvæ, either by cutting off the twigs which carry them and burning immediately, or burning the webs without pruning. If this work be done properly and against the early summer generation, the pruning method is unnecessary and inadvisable. By the use of a proper torch the webs and the caterpillars which they contain can be burned off at nightfall without necessarily destroying the life of the twigs, and a second crop of leaves will be put out a little later, so that the tree does not remain disfigured for any length of time. A bundle of rags wired to the end of a pole and saturated with kerosene makes a good torch for the purpose; or a porous brick wired to a pole and saturated with kerosene answers the purpose even better. Private persons will find this remedy sufficient. City authorities should apply an arsenical spray. Collecting the cocoons in winter may be carried on simultaneously with the collection of the egg masses of the white-marked tussock moth, but this, as well as other community remedies, will be referred to at another place.

THE RELATIVE IMMUNITY FROM INSECTS OF DIFFERENT VARIETIES OF SHADE TREES.

As regards a number of the principal shade trees that are most commonly grown, there does not seem to be any great preference on the part of the fall webworm and the tussock-moth caterpillar. If a moth happens to lay her eggs upon or near a given tree standing in a row, the species will naturally spread along the row before it will cross to the opposite side. In this way erroneous ideas of the relative immunity of trees have frequently been gathered.

Taking the insect question as a whole, however, there is a decided difference in the relative value of certain varieties. In December, 1893, the Tree Planting and Fountain Society of Brooklyn asked a number of experts to name for the use of the society nine of the most valuable trees for planting in Brooklyn. Three of these trees were to be large-growing, three medium-sized, and three small-growing varieties.

The reply of Mr. B. E. Fernow, Chief of the Division of Forestry in the United States Department of Agriculture, was comprehensive and of great value. He tabulated nearly 50 varieties, analyzing their good qualities under the different heads of endurance, recuperative power, cleanliness, beauty of form, shade, leaf period, rapidity of growth, and persistence, giving 3 as the highest mark for any one of these qualities and estimating the value of a given tree by the total number of marks given to it. This reply was printed and issued as a circular by the Brooklyn society. Mr. Fernow made no specific rating for immunity from insect pests, although in his introductory remarks he seems to have included the insect question under the head of cleanliness.

As is quite to be expected, the rating arrived at from the summing up of the qualities mentioned differs very considerably from the rating which might be arrived at from the quality of immunity from insects. Taking the large and medium-sized trees only (36 species in all), Mr. Fernow's rating stands as follows, only the total gained by the addition of the ratings in the several qualities considered being given:

Variety of tree.	Total rating (Fernow).	Insect rating (Howard).
LARGE-SIZED TREES.		
Red oak (*Quercus rubra*)	22	2.5
Scarlet oak (*Quercus coccinea*)	22	2.5
Yellow oak (*Quercus velutina*)	22	2.5
American elm (*Ulmus americana*)	22	1.5
Sugar maple (*Acer saccharum*)	19	2.5
Black maple (*Acer nigrum*)	19	2.5
Tulip tree (*Liriodendron tulipifera*)	19	3.0
European linden (*Tilia vulgaris*)	19	1.5
Small-leafed linden (*Tilia microphylla*)	19	2.0
Sweet gum (*Liquidambar styraciflua*)	19	2.0
White oak (*Quercus alba*)	19	2.0
Bur oak (*Quercus macrocarpa*)	19	2.0
Oriental plane tree (*Platanus orientalis*)	19	1.5
Kentucky coffee tree (*Gymnocladus dioicus*)	19	2.0
American plane tree (*Platanus occidentalis*)	18	1.5
Sycamore maple (*Acer pseudo-platanus*)	17	2.0
American linden (*Tilia americana*)	17	1.5
MEDIUM-SIZED TREES.		
Red maple (*Acer rubrum*)	22	2.0
Shingle oak (*Quercus imbricaria*)	21	2.0
Willow oak (*Quercus phellos*)	21	2.5
Slippery elm (*Ulmus pubescens*)	21	2.0
Norway maple (*Acer platanoides*)	20	2.0
Box elder (*Negundo negundo*)	20	.0
European elm (*Ulmus campestris*)	19	.5
Scotch elm (*Ulmus montana*)	19	1.0
Hackberry (*Celtis occidentalis*)	19	1.5
Silver-leafed maple (*Acer saccharinum*)	17	1.5
Tree of heaven (*Ailanthus glandulosa*)	16	2.5
Horse-chestnut (*Æsculus hippocastanum*)	16	2.0
Japanese sophora (*Sophora japonica*)	16	2.5
Hardy catalpa (*Catalpa speciosa*)	16	2.0
Gingko (*Gingko biloba*)	16	3.0
Honey locust (*Gleditschia triacanthos*)	15	1.0
Cottonwood (*Populus monilifera*)	15	.5
Balm of Gilead (*Populus balsamifera* v. *candicans*)	15	.5
Black locust (*Robinia pseudacacia*)	14	.5

The writer has made ratings of these same trees according to their immunity from the attacks of insects, the trees most immune being rated at 3 and those most attacked by insects at 0. The figures relating to insect attack are displayed above in a contrasted column next to the total rating, and in order that the relative importance from the insect standpoint may be seen at a glance the same trees have been rearranged in a separate table as follows:

Variety of tree.	Insect rating.	Variety of tree.	Insect rating.
Gingko (*Gingko biloba*)	3.0	Shingle oak (*Quercus imbricaria*)	2.0
Tulip tree (*Liriodendron tulipifera*)	3.0	Slippery elm (*Ulmus pubescens*)	2.0
Sugar maple (*Acer Saccharum*)	2.5	Norway maple (*Acer platanoides*)	2.0
[1] Red oak (*Quercus rubra*)	2.5	Hardy catalpa (*Catalpa speciosa*)	2.0
Tree of heaven (*Ailanthus glandulosa*)	2.5	European linden (*Tilia vulgaris*)	1.5
[1] Scarlet oak (*Quercus coccinea*)	2.5	American elm (*Ulmus americana*)	1.5
Yellow oak (*Quercus velutina*)	2.5	Hackberry (*Celtis occidentalis*)	1.5
Willow oak (*Quercus phellos*)	2.5	Silver-leafed maple (*Acer saccharinum*)	1.5
Black maple (*Acer nigrum*)	2.5	Oriental plane tree (*Platanus orientalis*)	1.5
Japanese sophora (*Sophora japonica*)	2.5	American plane tree (*Platanus occidentalis*)	1.5
Horse-chestnut (*Æsculus hippocastanum*)	2.0	American linden (*Tilia americana*)	1.5
Red maple (*Acer rubrum*)	2.0	Honey locust (*Gleditschia triacanthos*)	1.0
Small-leafed linden (*Tilia microphylla*)	2.0	Scotch elm (*Ulmus montana*)	1.0
White oak (*Quercus alba*)	2.0	Cottonwood (*Populus monilifera*)	.5
Sweet gum (*Liquidambar styraciflua*)	2.0	Balm of Gilead (*Populus balsamifera* v. *candicans*)	.5
Bur oak (*Quercus macrocarpa*)	2.0	European elm (*Ulmus campestris*)	.5
Kentucky coffee tree (*Gymnocladus divisus*)	2.0	Black locust (*Robinia pseudacacia*)	.5
Sycamore maple (*Acer pseudo-platanus*)	2.0	Box elder (*Negundo negundo*)	.0

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[1] This estimate of the red oak and scarlet oak was based largely on the beautiful condition of certain trees growing in the streets of Washington, D. C. Since the publication of the Yearbook article, however, several of these trees have developed rather serious cases of insect injury. The locust borer (*Xyleutes robiniæ*) has attacked a number of the trees, and although it is not apparently weakening their vitality to any serious extent, still it bids fair to do considerable damage. The trees have been treated by injecting a small quantity of bisulphide of carbon into the burrows and covering the opening with putty. In a few cases the obscure scale (*Aspidiotus obscurus*) has attacked these trees. It has not as yet killed any branches, but it multiplies as abundantly as its dangerous relative, *A. tenebricosus*, of the maple, and I see no reason why it should not be an equally injurious species. This experience somewhat shakes the confidence of the writer in his estimate of the rating of these oaks, but not to any very serious extent.

It will be noticed that the trees listed by Mr. Fernow which we find to be most immune are the gingko and the tulip tree. Outside of the grounds of the Department of Agriculture at Washington and Central Park, New York, few gingko trees are grown in this country, except as occasional isolated examples. The tree itself is a very beautiful one, and singularly free from insect attack. In the long double row of these trees, now nearly twenty-five years old, on the grounds of the Department of Agriculture, but one species of injurious insect has ever been found, and the work of this species is very insignificant. It is the little sulphur-yellow leaf-roller, *Tortrix sulphureana*.

The tulip tree, which is given the same rating, is, for practical purposes, almost as exempt as the gingko. Of late years in the District of Columbia it has been rather extensively infested by a plant louse (*Siphonophora liriodendri*), but although the lice occur on the leaves in great numbers, the general appearance of the trees has not suffered. There is a little gall midge which produces little black spots on the tulip tree leaves and disfigures them to some extent, and quite recently Mr. Schwarz has found that tulip scrub is affected to some extent in the District of Columbia by a little bark-boring beetle.

The box elder is a singularly unfortunate choice for a shade tree in this climate. It is almost defoliated by the webworm, it is sought after by the tussock moth, and various leaf-rollers attack it as well as certain destructive borers. In the West the box-elder plant-bug (*Leptocoris trivittatus*) breeds upon it in enormous numbers, and not only damages the trees to a serious extent, but causes much further annoyance by entering houses for hibernation.

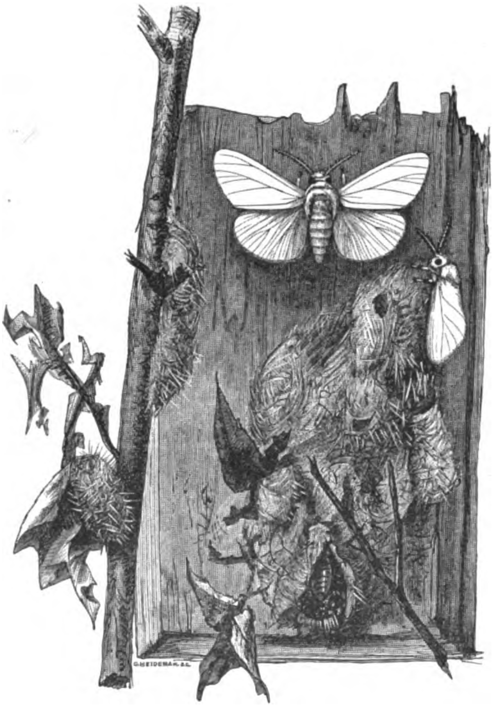

FIG. 9.—Fall webworm (*Hyphantria cunea*). Moths and cocoons—natural size (original).

The European elm is given a low rank, almost entirely on account of its annual defoliation by the imported elm leaf-beetle.

The honey locust and the black locust, while not defoliated to the same extent as many other trees by the webworm and the tussock-moth caterpillar, are rendered very unsightly almost every year by the work of a leaf-mining Hispid beetle and of certain Lepidopterous leaf miners. They are also frequently killed by the large Lepidopterous borer, *Xyleutes robiniæ*, and certain Coleopterous borers also infest them.

From the insect standpoint, there are several fine-growing ornamental trees on the grounds of the Department of Agriculture, not listed above, which are seldom attacked by insects. The beeches, hornbeams, alders, and magnolias have very few insect enemies, and are rarely defoliated by either of the principal leaf-eating caterpillars.

With regard to the extreme attractiveness which the European elm possesses for the imported elm leaf beetle, the question is frequently asked whether it would not be better to cut down all European elms growing in parks or in rows with American elms. Such a course, however, would seem to be undesirable. After the elm leaf-beetle has established itself in a given locality, it will attack the American elms to a very serious extent, in the absence of its favorite food plant. It is, therefore, better to allow a few European elms to remain. These will then act as trap trees, and the necessity for treating a large number of trees will in most cases be greatly reduced.

In selecting shade trees, particularly for small cities and towns in agricultural regions, and even to a considerable extent in large cities, the relative honey-producing qualities of the proposed shade trees is a matter of some little importance; not so much, perhaps, in the matter of actual food for the ordinary honeybee as in that of the increase of bees on account of their great value as cross fertilizers of orchard trees and forage crops. From this point of view, there are five very important honey producers among the principal shade trees. These are, in order of importance: American linden, tulip tree, black locust, horse-chestnut, and sugar maple.

GENERAL WORK AGAINST SHADE-TREE INSECTS IN CITIES AND TOWNS.

The question of proper work against the insects which affect shade trees in cities and towns naturally divides itself under two heads: (1) What can be efficiently and economically done by city governments? (2) If city or town administrators will not appropriate a small amount of money to carry on work of this kind, what can citizens who are interested in the preservation of shade trees do?

The planting of shade trees seems to be considered a legitimate function of the board of public works in every municipality. It is sometimes done by a specially appointed officer, under the control of the superintendent of streets and sewers; or it is placed in charge of a subcommittee of the board, or a special commission of outsiders is appointed to superintend the work. Admitting that the planting of shade trees is a public matter, their care should also be a public duty. Yet in not one of the larger or smaller cities of the Eastern United States with which the writer is familiar is any proper amount of work done by the public authorities against shade-tree insects. New York is the only city in the country where a man of entomological knowledge is employed to direct operations against shade-tree insects, either in the streets or the public parks. The writer does not wish to be understood as advocating the appointment of a paid entomologist by every city government, although where the parks are large in cities situated within the region of greatest shade-tree insect activity, such a course is always desirable. With an intelligent and industrious superintendent of parks, or a city forester, or whatever he may be termed, and the wise expenditure of a comparatively small amount of money each year, the shade trees of any city could be kept green throughout the summer.

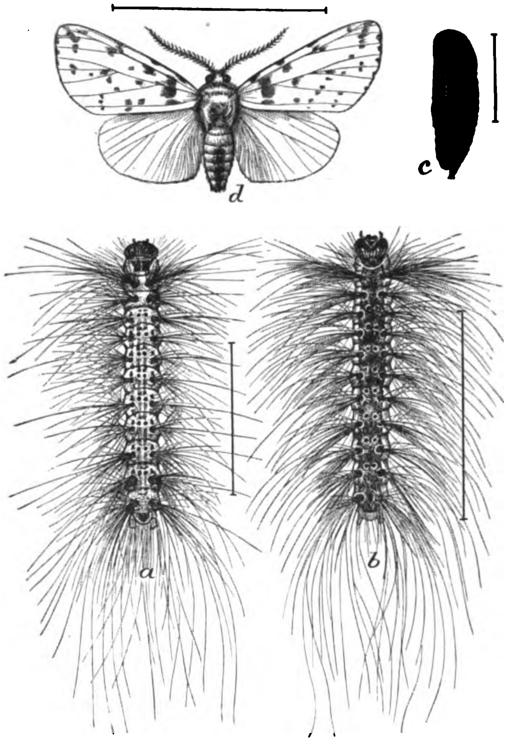

FIG. 10.—Fall webworm. *a*, light form of full-grown larva; *b*, dark form of same; *c*, pupa; *d*, spotted form of moth (compare fig. 9)—all slightly enlarged (original).

The amount of money to be expended in this direction would naturally vary with the number of trees to be attended to, as well as with the variety and the size of the trees and the geographical location of the city. Even in Brooklyn, however (and this seems to the casual observer to be the most unfortunate of all our Eastern cities from this standpoint), it is within bounds to estimate that the expenditure of $4,000 to $5,000 a year would result in green shade trees the summer through. This amount, moreover, will in all probability not need to be an annual appropriation. The first cost of a proper spraying apparatus will have to be added, but the apparatus once purchased and thorough work performed for two or three years consecutively, the probabilities are strong that the number of shade-tree insects would be reduced to such an extent that a considerably smaller annual expenditure would be sufficient.

The question of proper spraying apparatus is a rather serious one, since in this direction a considerable amount of money should be expended. A steam apparatus will do the work with much greater rapidity than a hand pump; and yet with a strong, double-acting force pump, which can be operated by a single man, and a tank of 100 gallons capacity, mounted upon a strong cart, many large trees can be well sprayed in the course of a day. From such a pump two lines of hose may be run with advantage.[1] The working force of such an apparatus should be a horse to draw the cart, a man to drive and do the pumping, and one man to each line of hose. Several such machines have been used with good results in the work of the Gypsy Moth Commission, both for street trees and in the public parks. A steam apparatus, however, of such a capacity that a pressure of 75 pounds per square inch may be gained will enable the operation of four or five lines of hose simultaneously. The rapidity of work will therefore be doubled, and certainly by the use of two such pumps the shade trees of any ordinary city can be gone over with sufficient rapidity to destroy all insects within the required time. A boiler mounted on a truck, the boiler to be complete with all fixtures, smokestack, bonnet, firing tools, springs to the truck, and a pump having a capacity of 10 to 20 gallons a minute connected with the boiler ready for operation, can be purchased for a sum well within $500. This truck should be mounted on wheels with broad tires, for running over sandy roads. Connecting this apparatus with a proper tank cart would be an additional expense, not to exceed $100 for a tank of a capacity of 200 gallons. Such an apparatus, furnished with hose and smoothbore nozzles of about one-sixteenth inch in diameter, when discharging under 40 pounds pressure from each of several such nozzles, would spray about half a gallon of insecticide mixture per nozzle per minute.

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[1] In the Yearbook of this Department for 1896 will be found an article by the writer entitled "The use of steam spraying apparatus," to which persons interested in such matters are referred in this connection.

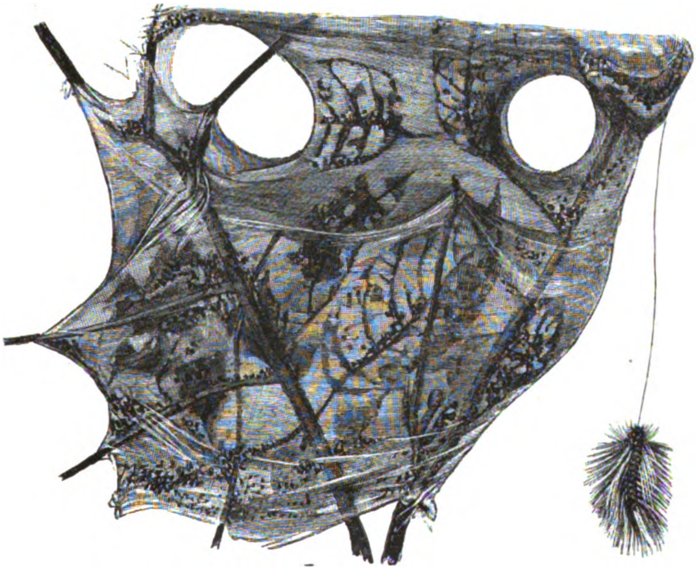

FIG. 11.—Fall webworm. Suspended larva and section of web—natural size (original).

A strong steam pump, to be used in connection with a small oil-burning boiler, the whole apparatus on a smaller scale than that described above, has been estimated at $275 by a prominent New York firm, delivered on board the cars.

There is no reason why an old steam fire engine could not be readily arranged for this shade-tree spraying work. In one or two instances a steam fire engine has been used for this purpose without modification, the object being simply to knock the insects from the trees by means of a strong stream of water. By such means as this the Superintendent of the Military Academy kept the elm trees green at West Point several years ago. In every large city, where the fire department is necessarily kept in the best condition, an engine is occasionally retired. The transfer of such a retired engine to the street department could no doubt be readily made, and a little work by a competent steam fitter could transform it into a most admirable insecticide machine. In this way the initial expenditure for machinery would be avoided.

When the spraying apparatus has once been provided, the funds necessary for the purchase of insecticides and the necessary labor at the proper time must be available. If the work is not done promptly and at just the right time, more or less damage will result, and a greater expenditure will be necessary. During the latter part of May and the first part of June, in the case of nearly all prominent shade-tree insects, one or two thorough sprayings must be made. In fact, a second spraying, begun immediately after the completion of the first one, will in ordinary cases be as much as need be expected. In addition to this spraying work, a force of men must be employed for a time in July to destroy the elm leaf-beetle larvæ as they are descending to the ground and to burn the webs of the first generation of the fall webworm. This will finish the summer work. The winter work will consist of the destruction of the eggs of the white-marked tussock moth, the cocoons of the fall webworm, and the bags of the bagworm. The number of men to be employed and the time occupied will depend upon the exigencies of the case. Upon the thoroughness of this work will depend, to a large extent, the necessity for a greater or less amount of the summer work just described.

We have now to consider what can be done by citizens where city governments will not interest themselves in the matter. It is unreasonable to expect that a private individual will invest in a spraying apparatus and spray the large shade trees in front of his grounds. Therefore, in spraying operations where large trees exist in numbers there must be combination of resources. This affords an opportunity for the newly invented business of spraying at so much per tree. A resident of Bridgeport, Conn., who was formerly, and is yet for the greater part of the year, a roofer and paver, has constructed several cart sprayers, and during the months of June and July (at a time, by the way, when the men in his employ are apt to be out of work) he sprays trees on the grounds of private individuals and along the streets in front of their grounds, under contract, at so much per tree, guaranteeing to keep the trees in fair condition during the season. His work has been directed solely against the elm leaf-beetle, since that is the only insect of great importance in Bridgeport. In the month of July, 1894, the writer, in driving through the streets of

Bridgeport, found it easy to pick out the trees which had been treated in this way. Such elms were green, while all others were brown and nearly leafless. The defect of this plan as a general practice lies in the fact that not all property owners or residents can afford to employ a tree sprayer, while others are unwilling, since they deem it the business of the city authorities, or do not appreciate the value of tree shade.

Any effort, therefore, looking toward the arousing of popular sentiment or the banding together of the citizens in the interests of good shade is desirable. A most excellent plan was urged by one of the Washington newspapers in the summer of 1894. It advocated a tree-protection league, and each issue of the paper through the summer months contained a coupon which recited briefly the desirability of protecting shade trees against the ravages of insects, and enrolled the signer as a member of the league, pledging him to do his best to destroy the injurious insects upon the city shade trees immediately adjoining his residence. This is only one of several ways which might be devised to arouse general interest. The average city householder seldom has more than a half dozen street shade trees in front of his grounds, and it would be a matter of comparatively little expense and trouble for any family to keep these trees in fair condition. It needs only a little intelligent work at the proper time. It means the burning of the webs of the fall webworm in May and June; it means the destruction of the larvæ of the elm leaf-beetle about the bases of elm trees in late June and July; it means the picking off and destruction of the eggs of the tussock moth and the bags of the bagworm in winter, and equally simple operations for other insects should they become especially injurious. What a man will do for the shade and ornamental trees in his own garden he should be willing to do for the shade trees 10 feet in front of his fence.

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U. S. DEPARTMENT OF AGRICULTURE.

FARMERS' BULLETIN No. 100.

HOG RAISING IN THE SOUTH.

BY

S. M. TRACY, M. S.,

Formerly Director of the Mississippi Agricultural Experiment Station.

WASHINGTON:
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U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF ANIMAL INDUSTRY,
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SIR: I have the honor to transmit herewith, and to recommend for publication as a farmers' bulletin, the manuscript of an article on Hog Raising in the South, prepared by Prof. S. M. Tracy, formerly Director of the Mississippi Agricultural Experiment Station. The bulletin contains much information in regard to the care, feeding, and breeding of hogs that will be valuable to stock raisers in the South and of interest to farmers generally.

Very respectfully,

D. E. SALMON, *Chief.*

HON. JAMES WILSON,
Secretary.

CONTENTS.

Page.
Introduction 5
General conditions 5
  Location and water supply 6
  Buildings and feed lots 7
Breeds and breeding 7
  Selection of a breed 8
    The perfect hog 8
    The Berkshires 9
    The Poland-Chinas 9
    The Duroc-Jerseys 10
    The Chester-Whites 10
    The Essex 10
    Other breeds 10
  Pure-bloods, crosses, and grades 11
    Pure-bloods 11
    Crosses 11
    Grades 12
  The boar and his treatment 13
  The breeding sow and her management 15
    Age at which to breed 15
    Young sows and old 16
    One litter or two 16
  Care of breeding sows and pigs 17
  Raising the pigs 18
  Castrating and spaying 20
Foods and feeding 20
  Permanent pasture 20
  Annual forage crops 21
    Artichokes 22
    Oats and vetch 22
    Sorghum and Kafir corn 23
    Cowpeas 24
    Sweet potatoes 24
    Peanuts 25
    Chufas 26
    Cassava 26
    Crimson clover 27
    Succession and rotation 27
  Grain and other feeds 28
    Corn 29
    Shorts and bran 29
    Cotton seed 29
    Skim milk 30

Foods and feeding—Continued. Page.
Grains and other feeds—Continued.
Salt and ashes 31
Cooking the feed 31
How and what to feed 31
Fattening for market 33
Diseases and insects 36
Hog cholera and swine plague 36
The hog louse 38
Statements of successful hog raisers 39
Conclusions 40

HOG RAISING IN THE SOUTH.

INTRODUCTION.

In the Southern States more pounds of pork are used than of all other meats combined. In a large proportion of the country homes beef and mutton are practically unknown, excepting occasionally in the winter months, and pork is almost the only meat food used by the large colored population. In every country store salt meat is as staple an article as is sugar or coffee; its cost is an important item of expense to the majority of housekeepers, and the demand for it seems limited only by the ability to purchase. Ten years ago fully 90 per cent of the pork used in the Gulf States was shipped from the great packing houses in Kansas City, Chicago, and Cincinnati, and little attention was given to its production here, few farmers growing even enough for their own consumption.

Since 1890, however, there has been a rapid increase in the number of hogs raised, a corresponding decrease in the amount of pork imported, and a still greater decrease in the living expenses of those who raise their own supply. Those who have engaged in raising hogs for the market have found it very profitable when rightly managed, and at the present time the business of raising hogs is increasing more rapidly than any other line of stock raising in the South. Conditions—climate, pastures, and grain feeds—are so different from those in the older hog-raising sections of the country that this bulletin has been prepared to describe some of the more economical methods peculiar to this region, as well as to give some general principles of breeding and management for those who have had but little experience in the work.

GENERAL CONDITIONS.

The hog is often called the "mortgage lifter" of the great corn belt from Ohio to Kansas, but its power in this direction is by no means confined to the region of cheap corn. The Southern States can produce corn almost if not quite as cheaply as the most favored regions of Illinois or Missouri, while the much greater variety of food crops, the more nearly continuous grazing, and the consequent greater immunity from disease give special advantages for profitable pork raising which do not exist elsewhere. Profit from the raising of hogs depends more on the supply of cheaply grown feed than on any other item. Food crops which are inexpensive to grow, which mature at different seasons, and which can be harvested by the hogs themselves are abundant in all parts of the South; and there is no reason why the Southern States should not be exporters instead of importers of meat.

LOCATION AND WATER SUPPLY.

For successful hog raising almost any location is suitable where there is a fertile soil on which food crops can be grown at a small expense and where an abundant supply of pure water can be secured. A good spring, or a small running stream which is not contaminated by drainage furnishes the best possible water supply. A large stream is undesirable, as it makes it difficult to keep the hogs fenced in, causes frequent losses by overflows, and often brings germs of disease from points nearer its source. The last objection is the strongest of all, as the germs of anthrax, cholera, swine plague, and other contagious diseases are often carried long distances by water, and such a possible source of infection should be carefully avoided. This spreading of disease by means of running water has been very plainly marked in nearly every outbreak of cholera in the hog-raising sections of the North, and though the disease is comparatively rare in the South, still it occurs occasionally, and its spread should be prevented by the use of every available means.

Shallow, stagnant ponds, in which the hogs are allowed to wallow, are equally undesirable and should never be tolerated. It is true that such ponds are in very common use and that many fine hogs are raised with no other water supply; but it is also true that such pools are always disease-spreading centers and are often responsible for serious losses which are attributed to cholera. No animal can be healthy or produce meat of the best quality when compelled to drink the putrid offal with which such ponds are always poisoned. Where a pond is the only available source for the water supply, it should be fenced so that neither cattle nor hogs can reach it, and the water should be drawn off into an outside trough as it is wanted. It is a small matter to provide for this when a dam is built by having a 1-inch galvanized-iron pipe laid through the bottom of the dam. The end of the pipe in the pond should be protected by a large strainer, and the outlet provided with an automatic float valve so that the trough will always be kept full, no water will be wasted, and a fresh supply will be drawn in as fast as the trough is emptied. The whole arrangement can be made at an expense of not exceeding $5, the value of a single half-grown hog, and will often save many times its cost in a single season.

It is not necessary that hogs should be provided with a place for wallowing in mud, as they will seldom wallow except when suffering from heat. A hog does not perspire freely, and so feels the effects of heat very quickly. When the only means for protection from the hot sun is to bury himself in mud, he will naturally do so. In the shade of a building he often misses the breeze, but in the shade of trees he will always be contented. An abundant supply of water and protection from the hot sun are both necessary, but should never be combined. With shade and good water provided, the other details of the location are of minor importance.

BUILDINGS AND FEED LOTS.

Elaborate and costly buildings are not needed, and, in fact, should be avoided. In the South it is rarely necessary to protect from cold, and all that is needed in the way of a building is something to furnish shelter from rain and a dry place in which the hogs can eat and sleep. Ordinarily a shed 8 by 10 feet, open on the south side, is all that will be wanted. This shed need not be more than 3 feet high at the back and 6 feet at the front, and should be floored. If the arrangement of other buildings is such that it is more convenient to feed from the south side, then that side should be closed by slats sufficient to control the hogs, but not close enough to shut out the sun and air, and at least one-half of the north side should be left open. In all cases the floor should be given a slope of at least 2 inches to the side opposite the feed trough to prevent the accumulation of filth. Such a shelter is ample for at least a dozen hogs, and when more are kept it is better to have additional separate shelters than to attempt keeping a larger drove in a single large building. Hogs always do better in small droves than when many are kept in one inclosure. Rough planks are all that is needed for the floor, as its main object is to prevent the hogs from making a dirt floor into a dust bed, which, next to impure water, is the most prolific cause of disease.

At the rear of each house there should be a yard large enough to give ample room for exercise, and if there is a number of these yards they should be arranged so that they can be thrown together and the hogs easily changed from one to another when desired. Whatever may be the arrangement of the yards, they should be surrounded by a fence so well made that it will offer no temptation to the most knowing animal. A hog which has never broken through a fence will seldom attempt to get out of his lot and will give very little trouble, but if he is permitted to break out a few times he will know that a fresh pasture and a change of feed are just on the other side of the fence, and will soon learn to go where he pleases.

BREEDS AND BREEDING.

The choice among different breeds is more a matter of personal preference on the part of the hog raiser than of real superiority in any one breed of hogs. Each has its peculiarities, its excellences, and its defects, and it can not be said that any one of them is always more profitable than another. Management and feed are more important than breed, and the choice should be decided by the treatment to be given.

SELECTION OF A BREED.

The more common breeds in this country are the Berkshires, Poland-Chinas, Chester-Whites, and Duroc-Jerseys, though Essexes, Suffolks, and a few others are occasionally seen. Thirty years ago the differences between different breeds were very marked, but with the greater attention which breeders have given to the production of animals possessing an ideal form the characteristics of the different breeds have approached each other, until now nearly all breeds have the same general form. Value in a hog of any breed is measured by his ability to make good pork, and experience has shown that, ordinarily, good pork can be produced more cheaply in a hog of a certain shape than in one which differs from the type to any great extent.

The Perfect Hog.—The outline of a perfect hog, when viewed from any direction, should be nearly that of a parallelogram with the corners slightly rounded. His back and belly, also his sides, should be straight and parallel; and, when viewed from front or rear, his outline should be nearly square, but a little deeper than wide. The head should be short; the face straight or somewhat dished and wide between the eyes; the ears should not be too large, should be thin, soft, and joined to the head by a small knuck. A large, coarse ear usually indicates a coarse animal which will fatten slowly. The jowl should be full, well rounded at the sides, and making a straight line from the tip of the lower jaw to the point of the breastbone. The neck should be short (the shorter the better), but well rounded, arched, and increasing in size from the head to the shoulders. The shoulders should be full and square, with the legs set well apart so as to afford ample room for the lungs and heart, and the heart girth just behind the shoulders should be nearly equal to the girth at any other point. The back should be broad and straight, and should be slightly arched rather than swayed between the shoulders and hams. The ribs should be well sprung to make the back broad, and should drop nearly straight at the sides. The belly should be wide and straight, not flabby nor drawn in at the flanks. The hams should be as wide as the shoulders, nearly flat across the top, and drooping but little to the root of the tail; they should be well rounded behind and come well down on the stifle, so as to make the lower part of the ham full and plump. The legs should be short, straight, set well apart, and strong enough so that the animal, even when well grown, will walk wholly on his feet and not upon his hocks and dew claws. The bristles should be fine, soft, and sufficiently thick to hide the skin. Coarse, stiff, erect bristles indicate a coarse animal which will mature late and unsatisfactorily, while if they are so few and short as to show the skin plainly they indicate a weak constitution and consequent liability to disease. Color has but little to do with the value of an animal, though there is a general prejudice in favor of black hogs for a warm climate. Buyers seldom make any difference in price on account of color, though there is usually a special demand for a few fancy white hogs about Christmas; but the scalding and scraping must be very carefully done or the skin will be reddened and so injure the sale in the local market. Packers pay no attention to color. The disposition of the hog should also be considered. An animal which is always uneasy, which is continually trying to escape from the lot, and which is inclined to fight and worry others, is too nervous to be a good feeder; on the other hand, a hog with too much of the opposite character, one which is rarely on his feet except while eating the food brought to him, will fail to make a satisfactory growth on pasture and will not take enough exercise for health. A medium between these extremes is a much better feeder than either.

The Berkshires.—The Berkshire is one of the oldest breeds, and one of the most popular in all parts of the South. Berkshires are of English origin, and were first brought to this country about 1830. They may be put in good condition for killing before they are six months old, but will continue to gain in weight until they are two years or more of age. They are good "rustlers" and will make a large part of their living in the pasture, but respond quickly to fattening food. They lose less in dressing than do most others, though a slightly greater proportion of their dressed weight consists of fat, which is better for making lard than for use on the table. The sows are very prolific and good mothers.

The Poland-Chinas.—The Poland-Chinas are the more popular breed in the corn belt of the North, and are about as numerous as the Berkshires in the South. They are a composite breed of recent origin which seems to have been developed naturally by the conditions existing in a region where corn forms almost the entire food. They originated in Ohio from miscellaneous crosses of the Big China, Irish Grazier, Poland, Byfield, and perhaps other stocks. The name of Poland-China was given about 1840 to a large, coarse black and white hog requiring about two years to mature, but growing to an enormous size, animals weighing 600 to 800 pounds not being uncommon. Crossing of these with Berkshires gave a smaller, finer, smoother, and earlier-maturing animal, closely approaching the Berkshire in form and color but still retaining a great part of its power of continuous growth up to three or four years of age, and dressing out a carcass nearly all of which is merchantable meat. While not as good grazers as the Berkshires, nor as well able to take care of themselves when turned into the woods, the Poland-Chinas of the present day have a quiet disposition, are easily controlled, grow rapidly, and fatten quickly. They appear to bear close confinement rather better than the Berkshires, and so are often preferred for pen raising. Usually the sows are not quite so prolific as the Berkshires, though some strains are very fertile breeders.

The Duroc-Jerseys.—The Duroc-Jerseys are large, long-bodied, red hogs, which are good feeders, easily fattened, and grow very rapidly when well fed. They have come into prominence during the last fifteen years, being descendants of the Jersey Red and the Duroc breeds, which have long been popular in Pennsylvania, New Jersey, and New York. The blending of the two has produced an animal which is easily kept or fattened, is small-boned, vigorous, and prolific. Being very long-bodied, the proportion of side meat to ham and shoulders is larger than in most other breeds, but many regard this as an advantage, and the breed is growing in favor wherever it has been introduced.

The Chester-Whites.—These are undoubtedly the most popular of the white breeds. They take their name from Chester County, Pa., where they originated by crossing the native white hogs with some large white hogs brought from England about 1825. Selection from the offspring of those crosses has made a great improvement on the form of the earlier animals, and has developed a hog quite similar to the Poland-China in shape, and differing from that breed but little excepting in color. Where any white hog is to be grown this is the best for general purposes.

The Essex.—This is a small black hog, of English origin, and is valued more for its quiet disposition, rapid growth when young, and early maturity than for its size or its ability to produce a large amount of meat. Where there is a local demand for well-matured hogs of small or medium size, or for pigs of which one or two are to be kept in a small pen and fed principally on slops from the house and the refuse from the garden, the Essex is a valuable animal, but is not generally popular for ordinary farm purposes, or for making large amounts of pork under ordinary conditions.

Other Breeds.—The small Yorkshires, Suffolks, Victorias, and perhaps other breeds are seen occasionally, but probably nine-tenths of the pure-bred hogs now in the South are either Berkshires or Poland-Chinas. The small breeds—Essex, Suffolk, and others—have never been popular in the South, as they reach a weight of 200 pounds little sooner than do animals of the larger breeds, while the latter, if allowed to live, will continue to gain in weight long after the others have ceased to grow.

As showing that there is practically very little difference in the meat-producing capacities of different breeds, Professor Henry, of the Wisconsin Experiment Station,[1] reports a test extending through two hundred and twenty-four days with a Berkshire boar and four sows, together with a similar lot of Poland-Chinas. The total gains and the amount of feed required for each 100 pounds of gain were as follows:

	Berkshires.	Poland-Chinas.
	Pounds.	*Pounds.*
Total gain of lot	1,167	1,168
Feed for 100 pounds of gain	512	524

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[1] Henry: Feeds and Feeding, p. 551.

The Poland-Chinas gained 1 pound more than the Berkshires and ate 12 pounds more grain for each 100 pounds of gain, but these differences are so slight that they can not be ascribed to the difference in breed, being more probably due to the individualities of the animals used. Many similar tests have been made at other experiment stations, but with no uniformity in results either in actual gains or in the amounts of feed required; hence it is safe to conclude that differences in breeds are more in form, disposition, and habits than in food requirements.

PURE-BLOODS, CROSSES, AND GRADES.

Whether it is most profitable to raise pure-bloods, crosses, or grades is a matter which is much discussed, but which can not be definitely settled in favor of either class for all cases.

Pure-bloods.—In general, good pure-blood animals of any preferred breed will be found more profitable than either crosses or grades, though a poor specimen of a pure-blood animal is no better than any other poor animal. The fact that an animal has a long pedigree and is registered in a herdbook does not in itself make the animal desirable as a breeder or profitable as a feeder. A desirable breeding animal must not only have the prepotency developed by generations of breeding to a certain definite standard, but must also have the form and characters of that standard in a sufficient degree so that it is itself a good specimen of the breed. Hogs are used for nothing except for the making of pork. The pure-bloods have been bred for many generations for that sole purpose. The best animals—those which had the ability to make a pound of meat from the least food in the shortest time—in each generation have been selected as breeders, while inferior ones have been rejected. In this way the natural tendency of the pure-blood animals of to-day has become so fixed by generations of selection that they make a rapid growth from a small amount of food. The "scrub," on the other hand, has been bred for the development of an animal which would, to a large extent, care for itself, while quick growth, good form, and easy fattening have been neglected, and the animal is to-day but little different from his wild ancestor. It has been literally "root, hog, or die," and the rooting form has been developed at the expense of the hams and side meat. When given an equal amount of food, the pure-blood will weigh fully twice as much as the native hog at six months or more, and when slaughtered will lose only 20 to 25 per cent of its live weight, while the native will not ordinarily dress more than two-thirds of its live weight. As the pure-blood will make more meat from the same amount of food and in less time than the scrub, it is the better animal.

Crosses.—It is a very prevalent idea that crosses make better animals than pure-bloods. It is argued that as Berkshires and Poland-Chinas are each good, a cross will possess the special good qualities of both, and so will be better than either. The crossing of two pure-blood animals of different breeds often gives pigs which are fine animals, have good forms, and will mature quickly and satisfactorily. When a litter of pigs is to be raised exclusively for slaughter, such crossing is not objectionable, and many careful hog raisers think it the better practice; but the pigs from such crosses, however good they may be, are of little value as breeders. The pure-blood ancestors on both sides have been developed toward certain definite but different ideals. In the first cross there seems to be a blending of the two types, and the results are often very satisfactory, but the offspring of these crosses are almost sure to show all the weaknesses and defects of both lines of ancestors as well as many of their own. Breeding from crosses, even though the individual animals may be of good quality, is rarely satisfactory or profitable.

Grades.—Good grades are much more reliable breeders than are crosses and are to be preferred. The native stock has the vigor of constitution, which is always necessary, and has no inherited prepotency to develop in any certain direction. When mated with a pure-blood, the result is usually an animal with the vigor of the native ancestor and the characteristics of the pure-blood parent shown in its better form and fattening qualities. Succeeding crosses in the same direction strengthen this tendency toward improvement. The great objection to "grading up" in this way is the fact that, no matter how fine specimens the animals may be, they can never be sold as pure-bloods, and an animal which is a grade will never sell for breeding at as high a price as will one which is of pure blood and entitled to registration. The man who intends to follow hog raising as a business, even if he does not keep more than a dozen animals, will find it both profitable and economical to buy a pair of pure-bloods, and then make his entire drove pure-bloods as soon as he can raise enough desirable animals. By buying a young boar and a sow already in pig by a boar not related to the one purchased, the boar can be used on the offspring of the pure-blood sow as well as upon the grades or natives in the herd, and in this way the pure-bloods can be increased so rapidly that there will soon be no need to keep the grades. The hog raiser should certainly use a pure-blood boar, and it will usually pay to buy a new one each year, so that inbreeding may be avoided. Pure-blood hogs are not necessarily expensive. They pay best in the end, and so are more profitable than either crosses or grades. Good animals, though not the best, of any of the standard breeds can be purchased for from $5 to $10 each when weaned, while young sows in pig can be bought for from $10 to $20. Of course older animals which show specially fine qualities will cost more, and their better qualities will often make them the more profitable in the end. Breeders who have established reputations as producers of exceptionally fine animals usually receive much higher prices than those named above, but often a man who raises hogs for production of pork only, and who does not care for a reputation as a breeder, will sell good breeding animals for little more than their pork value.

THE BOAR AND HIS TREATMENT.

Hogs intended for breeding should be selected from the very best in the drove. No one can afford to raise pigs from animals which refuse to fatten, which are frequently "off their feed," or which have in any way shown anything but the most vigorous health. The breeders should be the squarest built and best shaped animals in the lot. They should be hearty eaters, and should show a tendency to lay on fat rapidly.

Blood tells in hogs as well as in horses, and to save a sow for a breeder simply because she is not fat enough to kill when the others in the same lot are ready for market is one of the surest ways to secure inferior pigs.

It is usually better to buy a boar than to use one which has been raised on the place and is related to the sows which are to be bred, as the introduction of fresh blood will give larger litters and more vigorous pigs than can be expected from any close inbreeding. This is one of the principal reasons why the first crosses between different breeds are usually so satisfactory, and the offspring of such crosses, when bred among themselves, are so unsatisfactory. The breeding sows can usually be selected from those in the drove, but a new boar should be purchased as often as the sows have passed their prime and are replaced by the offspring of the old boar. If hogs are grown for the market only, it is not necessary to pay a fancy price for a fancy animal which has every bristle of just the right color and pointing in exactly the right direction. The man who is raising hogs to be sold as pure-bred breeding animals can not be too careful to purchase only such as come nearest the ideal shape, color, and style typical of the breed he is using; but for the man who is raising pork and who does not expect to sell fancy breeding animals, slight variations in color, shape and position of ears, and length of tail are of little importance. What the pork raiser should require in his boar is good form and size without coarseness, good feeding capacity, and a strong constitution. A short neck and short legs usually indicate good fattening qualities, and so are important requisites; they are even more important in the boar than in the sow. The boar should be small-boned for his size, but it is all important that his frame should have sufficient strength to carry him well on his feet.

Among the points to be avoided in choosing a boar are a long head, neck, and legs, as such a form indicates an animal which will require a large amount of feed to produce a pound of meat, and one which can not be finished off for market until he has reached considerable age. Walking partially on the dew claws shows weakness of frame, and indicates a poor grazer and an animal which will break down before he reaches a heavy weight. In a young boar the shoulders should not be broader than the hams. The back should not be swayed, nor too strongly arched, though a back which is moderately arched is much less objectionable than one which is swayed.

In breeding for pork the boar need not have all the finer markings of his breed. Color of hair on the hog makes no difference with the quality of the pork, but he should have a good form, and should be decended from animals having good forms. A poor specimen of a pure-blood animal is little better than a scrub, and should not be used simply because he has a long pedigree. Pedigree is good because it gives prepotency, but form and vigor are better because they give pork. Good shape is absolutely necessary in a good boar, and if he has a good pedigree also he is a much better animal.

Nearly all breeders of fancy stock have numerous boar pigs which are not quite up to the standard in some unimportant particulars, and so can not be sold as strictly first-class animals. The defects may be nothing more than a slight variation in color, swirls in the bristles, or a missing tail; but with even such defects the animals would stand a poor chance in the show ring, and breeders are often glad to sell them for little more than their value for pork. Such animals are just as good as any where pork and not show is wanted, and will insure much better pigs than can be expected from an equally well-formed grade or an inferior pure-blood.

The man who is raising hogs to be sold for breeders can not be too careful to use only such as come nearest the ideal for the breed; hence, from his point of view, defect in color, swirls, or a missing tail would be a serious blemish to the animal. The breeder of breeding animals can well afford to pay a relatively high price for an animal which is free from these minor defects, as his sales will depend largely on the general appearance of his herd, while the hogs of the pork raiser are sold by the scales.

Boars should not be purchased until they are four or five months old, as they do not show their form fully before that time. They cost less at weaning time, but their purchase at that time is a lottery, as a promising pig often develops into an inferior and poorly shaped animal. It is not safe to delay the purchase until the boar is wanted for service, as others will be wanting him at the same time, and there may be delay in finding a desirable animal. The service is more sure and the boar can be handled with much less trouble if he has been on the place for a few weeks before he is needed for use. He should have time to become accustomed to his new quarters before he goes to service.

The boar should never be allowed to run with the sows, as he will be a continual worry both to them and to his owner, and it is much better to keep him in a lot where he can neither see nor hear other hogs. He should be kept as quiet as possible, and his food should be such as will give him strength and vitality, but not too fattening. He will do better service when he has sufficient grazing to give him exercise and only sufficient grain food to keep him in good condition without becoming so fat as to be heavy and unwieldy.

THE BREEDING SOW AND HER MANAGEMENT.

The sows for breeding can usually be selected from the drove. As "like produces like," they should always be selected from large litters from sows which are good milkers and good mothers. The gilts selected should be good feeders and have the prospect of becoming good milkers. A sow which is not a good feeder will produce only small litters, will be a poor milker, and her pigs will never make the quick and even growth necessary for good profits. It is impossible to judge accurately of the milking qualities in a gilt, but usually a chunky, easily fattened, heavy-boned, and short-legged sow is not as good a milker as is the less attractive-looking one with a longer body, longer legs, and somewhat less rounded sides. Form should not be wholly sacrificed to the production of large litters and abundant milk, but good milking capacity is essential to a good sow. If the pigs are not able to get all the milk they need during the first six weeks of their lives, they become stunted in a way from which they never fully recover, and many pigs which die before they learn to eat solid food die of starvation. A sow which is a good milker is usually a prolific and careful mother also.

Many defects of form in the breeding sow may, to a great extent, be corrected in her offspring by mating her with a boar which is unusually strong where she is weak. If the sow is too long-headed, long-necked, and long-bodied, she should be mated with a boar having the opposite characteristics; if the sow has weak legs and her dew claws touch the ground the boar should have unusually strong and straight legs; if the sow is sway-backed the boar should have his back well arched. On the other hand, a boar which has weak points can often be used with success on a sow which is unusually strong where the boar is defective, though a weakness in the boar is not counterbalanced as readily as one in the sow, on account of his greater prepotency. A boar and sow having the same defects should never be mated, as similar defects are almost certain to be greatly exaggerated in the pigs.

It should be remembered that the boar gives half the blood to the whole herd, while the sow can influence only her own litter. For this reason it is highly important that, whatever the sows may be, the boar should be one which will give vigorous pigs of good form. As nearly all the breeding sows in the drove at any one time will be the offspring of a single boar, and so will have a strong resemblance to each other, it will not be difficult to select a new boar which will be a fairly good mate for all.

Age at Which to Breed.—No uniform rule exists in regard to the age at which a sow should be bred the first time, as more depends on the maturity of the animal than on the number of months it has lived. In the South it is usually more profitable to raise two litters yearly, having them come about April and October. Where this is practiced, sows raised on the place must be bred when they are either 8 or 14 months of age, and the younger age is usually the better. A pig which has been properly cared for will weigh over 200 pounds at that age, and is sufficiently matured to produce a fair number of vigorous pigs. If not bred until 14 months old she may have one or two more pigs in her first litter, but even that is uncertain, and during her six months of waiting she will have earned nothing. A sow which has her second litter at 18 months will usually have more pigs than one which farrows then for the first time, and during the previous six months will have raised a number of pigs, which will be worth much more than the cost of her keep.

Young Sows and Old.—The number of litters which a sow should be allowed to have before she is fattened for butchering depends on the animal herself. When a young sow has only four or five pigs, or shows herself to be a poor milker or a careless and indifferent mother, the sooner she is fattened the better; but if she does fairly well she should be given a second trial. The second litter is usually larger than the first. If she then proves a good mother and her pigs from both litters develop into good porkers, she should be kept as a breeder until she can be replaced by a more prolific and better animal. An old sow which regularly raises large litters of good pigs is worth half a dozen untried gilts. An aged sow mated with a young boar will produce pigs which will mature earlier than those produced when the sow is young and the boar aged, which is a strong argument in favor of keeping a sow as long as she continues to breed satisfactorily. Ordinarily sows cease to be profitable breeders after they are 4 or 5 years old, but some raise good litters after they reach 8 or 9 years. When a sow more than 4 years old fails to give a good litter whenever it is due, she may as well be fattened at once.

One Litter or Two.—Whether it will be better to have one litter or two each year is a matter which each hog raiser must decide according to his own conveniences. When comfortable shelter is provided and good winter pastures can be secured, October pigs are usually as profitable as those which are farrowed in the spring. By the time they are ready to wean, oats and vetch should be in good condition for grazing, and the young pigs will soon begin to eat artichokes so they need not be confined to dry feed. By spring they will be large enough to kill for a local market, or they can be kept growing through the summer with very little expense. By December they should weigh at least 300 pounds each, and be ready for market. In every town there are butchers who are always watching for opportunities to buy pigs weighing from 100 to 200 pounds for the local trade, and October pigs will often bring high prices for meeting that demand.

March or April pigs come at a season when they need little care, and can be carried through the summer at a very small cost. By December, if they have been well fed, they will weigh from 250 to 300 pounds each, and at eight months will be fully as profitable as the heavier October pigs, which have been kept fourteen months.

When only one litter is raised yearly it should come as early as h, and often February is the better month.

CARE OF BREEDING SOWS AND PIGS.

During the four months the sow is carrying her pigs she needs good care, as she not only requires support for herself, but must have such an abundance of nourishing food as will enable her to produce healthy and well-developed pigs. During the first two months no change need be made in her usual food, and she can be left with the rest of the drove without danger, but as her time for farrowing approaches she should have somewhat different treatment. She should be kept in a separate lot from the fattening animals, as she will need different feed, though several pregnant sows can be kept in a lot together without danger. From this time onward her food should be such as will produce bone and muscle rather than fat, but she should never be allowed to become thin in flesh. Bran, shorts, shipstuff, ground oats, and pease should constitute the principal part of the grain feed, and but little corn should be used. Fresh green feed is especially needed at this time, and if grazing is not convenient, green feed should be cut and fed liberally.

A week or ten days before farrowing she should be put in a pen by herself so that she will have time to become accustomed to her new quarters before the pigs appear. The farrowing pen need not be large, 10 feet square is ample, but it should be where she will not be disturbed by other animals. The pen should have a floor, and running around the sides a 12-inch plank should be fastened 6 or 8 inches above the floor to afford the pigs a safe place where the sow cannot crush or smother them. It takes the pigs only a day or two to learn the value of this protection, and it will often save much more than its cost. Little or no bedding should be used. The feed at this time should be strengthening but not heating, and if any indication of costiveness appear she should have a good feed of wheat bran. A constant supply of salt and ashes is specially needed at this time to satisfy the craving for such food which often makes sows eat their young. Eating her young pigs is an unnatural act on the part of the sow, and is almost invariably the fault of the feeder in not giving her the food needed to satisfy a natural appetite.

When the sow is about to farrow, from one hundred and twelve to one hundred and sixteen days from the date of service, she should be given only light feeding, but should have all the water she wants. If she has had proper feed and treatment she will rarely need assistance in farrowing, but the owner should be at hand, watch her closely, and be ready to give help if needed. If it is very cold the pigs should be taken away as fast as they are born and put in a warm basket, but should be returned to the sow as soon as she is through. It is true that many sows which run in the woods and are never looked after before farrowing will make nests in fence corners or behind logs and come up with fine litters of thrifty pigs, but it is also true that a still larger number of those which run at large crush or smother many of their young and lose others from various accidents which might easily be prevented. If young pigs are worth breeding they are worth caring for, and when the farrowing is properly looked after the losses will be very small.

After farrowing the sow should be given nothing but water or a little thin slop during the first twenty-four hours, and should be fed only lightly for several days. After the end of the first week her food should be increased as rapidly as is safe, and should consist of shorts, oats, and similar foods which will stimulate a flow of milk. The feeding of the sow during the first month after farrowing is of more importance than at any other time, as the vigor of the pigs depends on the amount of milk they receive from their dam. If the supply is too small, they are stunted so that they can never make the most profitable feeders, while if the supply of milk is too large, the pigs are almost sure to become affected with scours and receive a setback from which they are slow in recovering. It needs close watching and good judgment to give the sow just the right amount of food to keep both her and her pigs in the best condition. The amount of grain should be increased with the growth of the pigs, and green feed should be given liberally. A good start is necessary to the most rapid growth of the pig, and as the young pig must make its entire growth on food received through the mother it is poor economy to save feed on the sow at the expense of the future of her entire litter. After the first week there is less danger that the sow will be fed too much than that she will not be fed enough. If she should be overfed and the pigs show any indication of scouring, she should have less feed and be given strong lime water to drink. If the pigs are old enough to drink, they should be given scalded milk in which a little wheat flour has been mixed, and an egg stirred in with the milk for each two pigs will be beneficial. If the pigs are too young to drink they should be given four or five drops of paregoric.

RAISING THE PIGS.

The pigs will begin to eat when they are about three weeks old, and the more they can be induced to eat the more rapid will be their growth. A feeding place should be provided for them adjoining the pen in which the sow is kept, and so arranged that the pigs can go in and out at will without being disturbed by the sow. A few grains of soaked corn scattered over the floor will soon get the pigs in the habit of eating and they should be encouraged to eat as much as possible. As dry corn will hurt the teeth and make the mouth sore, shorts or oats should be given in the place of soaked corn as soon as the pigs learn to eat fairly well. When the pigs begin to drink they should be given all the skim milk they want if it can be had, and if it is not available they should have a thin slop made of water and shorts. Corn meal is too fattening and is poor feed for young pigs.

By the time the litter is three weeks old both the sow and pigs should have the run of a lot where they can get sunshine, exercise, and fresh grazing, though the pigs should still have the feeding place where the sow can not come and should be fed regularly with all they will eat of food which will give them bone and muscle but will not be too fattening. Shorts, ground oats, and pease are the best grain feeds, and skim milk is worth more to a pig during the months before and after weaning than at any other time. Corn and rice are of little value for making growth. Bran is so harsh that it often causes irritation of the bowels, and is not a safe feed for a pig under three months old. Good grazing will make the larger part of the growth, but the pigs need grain feed also to make them do their best.

With such grazing as will be afforded by oats, vetch, and artichokes during the winter, and by alfalfa, clover, melilotus, and other crops in the spring, together with skim milk and such grain feed as has been named, the pigs will be well able to feed themselves by the time they are eight weeks old, and neither they nor the sow will hardly know when they are weaned. Pigs which have never been encouraged to eat, and are largely dependent on their mother's milk for food often receive a severe check when they are weaned suddenly, and every day in which a pig does not grow adds that much to the expense of raising him. By giving the pigs all the solid food they will eat while still sucking they become accustomed to it gradually, and when the time comes to separate them from the sow at about the end of the eighth week they are so well prepared that they scarcely notice the change.

If the sow has been well fed while suckling the pigs she will have made a fair gain in weight during the last month, and after the pigs are weaned she should be given more fattening food to prepare her for raising another litter, or as the beginning of her fattening for market. When a sow has an abundance of good grazing, and not more than half her grain feed is corn, she will not become too fat for breeding. In fact a sow is rarely too fat for breeding, although there is a common prejudice to the contrary. So long as she continues in good health and is making a fair growth her fatness will not make her less prolific, and she will usually produce larger litters and stronger pigs than when thin. This is especially true of young sows, and with such feed as has been recommended no sow will become too fat before weaning her second litter. The sow will usually come in heat in from one to two weeks after her pigs are weaned, and, if she is to be bred again, should be served at the first opportunity.

The pigs should be pushed as rapidly as possible after weaning, for the sooner they can be made to weigh 200 pounds each the more profitable they will be. Good pastures and good water are necessary for health and making a satisfactory growth, but in addition to these the pigs should have a liberal supply of bone and muscle-making food. Shorts, ground pease, peanuts, and other feeds rich in protein, together with skim milk when possible, are the best feeds for growth, and an exclusive corn diet is the poorest. Pigs will fatten rapidly when fed on corn alone, but the fattening will be at the expense of health and growth, and there will be many deaths from apoplexy before the pigs are six months old.

CASTRATING AND SPAYING.

Young boars not wanted for breeding should be castrated as early as is convenient. This may be done at any time after the pigs are a month old, and if done at from four to six weeks they will have fully recovered before they are weaned. If not done then it is better to wait until a month after weaning, so that they will have become thoroughly accustomed to eating solid food.

Spaying young sows is no more difficult or dangerous than castrating young boars, and should be more generally practiced. It can be done best when they are between 3 and 4 months of age, and, as the young sows are liable to get with pig at any time after they are 4 months old, the spaying should not be delayed too long. By the time the pigs weigh from 75 to 100 pounds each they will be developed sufficiently to show which should be kept for breeding animals, and the sooner the others are spayed the better. Spayed animals are always more quiet and better feeders than open sows, make better pork, and sell for better prices. A spayed sow weighing 200 pounds will dress from 10 to 20 pounds heavier than an open sow of the same live weight; she will have heavier leaf and inside lard, and there will be no danger of loss from finding her in pig. Packers and butchers will always pay top prices for spayed sows, because such animals are sure to be as good as they look, while they will often refuse to purchase open sows at any price, or will take them only with a heavy allowance for shrinkage.

FOODS AND FEEDING.

The economical and profitable production of pork requires that the feed should be palatable, nutritious, and inexpensive. No one kind of feed can be used exclusively with profit for feeding pigs, breeding animals, and fattening hogs, and no one feed will continue to be as palatable as a variety of feeds. It should be the object of every hog raiser to induce his animals to eat as much as possible, and the greater the variety the greater will be the amount of feed consumed. The cheapest and most profitable feed is that which can be grown with little labor and harvested by the hogs themselves, though it is economy to supplement each grazing crop with grain and other feeds suited to the condition of the animals.

PERMANENT PASTURE.

Hog raising can seldom be made profitable without a good permanent pasture, where the hogs can secure a large part of their coarser food at a nominal cost, and where they can have the exercise which is absolutely necessary to good health. If the hogs have an extended range, as in woods and canebreaks, they will make fully half their growth without further cost, and when such a range is not available pasture should be provided. There is no other grazing plant which will give so much hog food per acre through a large part of the year as alfalfa, and on soils where it can be grown it will pay well to provide the hogs with such a pasture. The soil for alfalfa should be sandy rather than heavy clay, and the subsoil must be well drained or the plants will be short lived. Good alfalfa soils are found in all parts of the South along the rivers and larger streams, on the marl hills, in the rotten limestone regions, and in the sandy hill lands of the middle district. The man who has land suitable for an alfalfa pasture need have no trouble in making pork profitably. Where alfalfa can not be grown Bermuda grass, lespedeza, and melilotus are excellent substitutes. The hog is naturally an animal which feeds over a wide range, and, although the food which he gets from the native pastures or even from alfalfa will not alone enable him to make the rapid increase desirable, still it is essential to health and will form a good part of the bone and muscle needed for satisfactory growth. A good pasture is as necessary for profitable hog raising as for the growing of beef animals, and no one should attempt to grow pork for market without providing at least one field where the hogs can have abundant exercise and can find enough roots and herbage to keep them in health.

ANNUAL FORAGE CROPS.

While a permanent pasture is essential, temporary grazing crops will do much toward reducing the cost of making pork. There are a number of easily grown crops which furnish not only coarse forage, but also a large part of the grain feed which will be needed, and a selection can be made which will give a succession lasting nearly or quite through the year in a region where the ground is so rarely frozen. Oats and vetch, sorghum, corn, sweet potatoes, cowpeas, peanuts, and artichokes all make excellent feed, can be grown with little expense, and in nearly all localities will make fields which can be grazed with profit from January to December. Other crops, like crimson clover, chufas, and cassava, have been found very profitable in some localities, while the gleaning of the corn and other fields always gives a good amount of inexpensive meat. It is always well to grow a variety of these grazing crops rather than to have a larger acreage of only one or two, as the greater variety not only gives a better succession of growths, each of which is grazed when in its prime, but gives better results in meat produced per acre.

Hogs are wasteful grazers when turned into rank pasturage, and a great saving of feed can be secured by growing the different grazing crops in long, narrow fields, which can be divided into sections by movable transverse fences. Usually there will be no trouble in arranging the fields so that this may be done, while, by maintaining a succession of plantings, and by fencing the hogs away from such recently grazed crops as oats, sorghum, and others which will make a second growth, the fields need not be large. By frequent changes of the feeding ground, 1 acre will yield abundant grazing for at least ten full-grown hogs, or for a correspondingly larger number of younger animals and pigs.

Artichokes.—For winter and early spring there is no better crop than artichokes, which give a rich, fresh feed just at the time when grasses and clovers are at their poorest. There are few crops which can be more easily grown on any fairly good soil which will give a greater amount of green feed per acre and be more valuable for both growing and fattening animals. They should be planted in drills like Irish potatoes, the seed being cut in the same manner, and about the same amount being used per acre. Two cultivations will usually be sufficient to keep the ground mellow and free from weeds until the plants are so tall as to shade the ground, after which no further working is needed. The tubers do not form until late in the season, and in this latitude are rarely matured before the 1st of December. Even then they are not relished as well as they are later, and as they keep well in the ground until late in the spring, it is usually better to save them for January and February grazing, after the sweet potatoes, peanuts, and other crops are gone. Although the artichokes will make a volunteer growth from the scattering tubers left in the ground, such a crop can not be cultivated, and will be so choked by weeds and dwarfed by the hard ground that the yield will be small. It pays well to plow and replant the crop each season, even though it is planted on the same ground. Many object to artichokes for fear they will become a troublesome weed, but there is no danger from that source. If the young plants are plowed or even hoed off well in midsummer after the old tubers are exhausted and before the new ones are formed, they will be killed. The yield is variable—from 400 to 800 bushels per acre—and its feeding value is fully equal to that of other root crops. In some recent tests at the Oregon Station hogs which were given the run of an artichoke field, and were also given a partial feed of grain, made a gain of 1 pound in weight for each 3.1 pounds of grain fed, while it usually takes about 5 pounds of grain to make 1 pound of gain. In tests made at the Missouri Agricultural College 1 bushel of artichokes and 3 bushels of corn were found superior to 4 bushels of corn, and other tests have given similar results. The inexpensive gain in weight is not the only advantage in using artichokes, as the better health consequent on adding to the ration this fresh and succulent feed is a matter of great importance, especially in animals which are kept for breeding. The best soil for the crop is similar to that which is best for Irish potatoes. It should be rich, mellow, and well drained. On dry, hard clay the yield is always small.

Oats and Vetch.—A mixture of turf oats and hairy vetch, sown in October or November, makes an excellent grazing crop for use after the artichokes are gone. When sown on fairly good corn ground this crop will have made such a rank growth by February that it will furnish good grazing during the next two or three months. The turf oats bear grazing better than does rye or barley, are less easily injured by freezing, and will continue their fresh growth much later in the spring. It is undoubtedly the best grain crop we have for grazing. The vetch also makes a vigorous growth, and, pound for pound, gives a feed richer in protein or muscle-forming material than any other common pasture plant.[1] Its unusually large proportion of protein makes it specially valuable for young and growing animals, and it gives the very best of early grazing for fall pigs which are to be kept through the summer. When the oats begin to head and the vetch to flower, in April, stock should be taken off, so as to allow the plants to mature seed, which they will do late in May or early in June. The ground should then be plowed and planted in cowpeas or some other summer crop which can be cut for hay or grazed off in September and October, after which the vetch seed left in the ground, and usually the oats also, will make a volunteer growth fully as good as that of the previous season. The writer has used this rotation six years without replanting the vetch and there has been an almost constant increase in the yield. In some seasons the volunteer oats have failed to make a full stand, but the vetch has never failed to make a satisfactory growth. One bushel of the oats and 1 peck of vetch seed are sufficient to seed an acre. The soil should be a rich loam which is not too light. The vetch has not often been satisfactory on sandy soils, but recent experiments at the Alabama Station[2] show that by proper inoculation such soils will produce abundant yields. By the time the hogs are removed from the oats and vetch the permanent pastures will be in fine condition and will give good grazing for many weeks. This will be especially true where alfalfa, melilotus, and clovers are grown, and at this time but little grain need be fed. During the early summer months growth of bone and muscle are more important than the accumulation of fat, and, although it pays to feed a little grain at all times, the amount used during the early summer may safely be less than at any other season.

Sorghum and Kafir Corn.—Sorghum and Kafir corn are the best crops for early summer grazing, and by a succession of plantings will continue to furnish feed until late in the season or until killed by frost. The two crops are very similar and require the same treatment, sorghum being of the quicker growth and making the better summer food, while Kafir corn will make the better growth in the dry weather of early fall, and its heavier yield of seed, which matures just as the fattening period begins, makes it very valuable. The sorghum should be sowed broadcast at the rate of one bushel per acre as soon as there is no further danger from frosts, and will make fair grazing in four or five weeks. As it is killed by too close grazing or by rooting, the field should be grazed in sections. If the field is arranged for temporary cross fences, as suggested on a previous page, it is better to keep the hogs on each section only a week and then give the plants three weeks to recuperate and make a new growth. When treated in that way a small field may be grazed down two or three times, and a single planting will furnish feed at least two months, while later plantings treated in the same manner will still further prolong the season. Kafir corn may be planted at the same time as sorghum, but, as its greatest value is for grazing in late summer and early fall and for its seed, it is usually planted much later, and should be planted in drills, so it can be cultivated. The stalks are less sweet and so less valuable than those of sorghum, but it makes a greater weight of leaves per acre, and its yield of seed is fully one-half greater than that of sorghum. Being such a drought-resistant plant and producing such a heavy yield of seed (from 30 to 50 bushels per acre), it is often grown mainly for its seed, while its forage value is regarded as a secondary matter. In one test at the Kansas Experiment Station[1] 100 bushels of Kafir corn seed was found to equal 83.7 bushels of corn for fattening hogs; in another test at the same station 100 bushels of Kafir corn seed equaled 84.8 bushels of corn; while in a third trial, with pigs soon after weaning, 100 bushels of the seed equaled 90.4 bushels of corn. At that station the average yields per acre for nine years had been 45.9 bushels of Kafir corn seed and 34.2 bushels of corn; or if expressed in pork, the yields have been 454 pounds of pork per acre from Kafir corn and 402 pounds from corn. In many places in the South the difference would be still more marked in favor of Kafir corn, as it will grow and yield much better than corn on thin clay hills, which are specially subject to injury from drought. Where the southern hog-raiser has rich, moist bottom lands on which to grow corn and forage, Kafir corn has no marked advantage over sorghum, corn, and other crops.

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[1] Experiment Station Record, Vol. VI., p. 98.

[2] Bulletin No. 96, Alabama Experiment Station.

Cowpeas.—Cowpeas give rich grazing from July until October, and should always be grown for use during late summer and early fall. Being very rich in protein, they make an excellent food for growing animals, though not desirable as the exclusive feed in the final fattening, as the fat meat produced by them is too soft and oily to be of the highest value. Lots for early use may be sown on the ground from which artichokes were harvested, and will be ready for use in two months from planting. For later use some of the quick-growing sorts may be planted on the vetch ground, or, if the ranker-growing and later-maturing sorts are sown on the artichoke ground or elsewhere, they will make an immense growth of forage for use in September and October. Usually, however, it is better to sow the peas for late grazing in the cornfield than to use land for that purpose alone. With the earlier-ripening varieties of peas and sorghum the hogs will be carried up to the beginning of cool weather without trouble.

Sweet Potatoes.—For September, October, and November the best three crops are sweet potatoes, peanuts, and chufas, and as the soil becomes more sandy they become of more importance. All grow well in soils which are quite light and sandy, while none of them is worth planting on heavy soils. Sweet potatoes make the best root crop which can be grown for fall use in the greater part of the South, being less expensive to cultivate, yielding more heavily, and being richer feed than beets, turnips, or rutabagas. In some sections of Florida, and along the Gulf coast, cassava is often a better crop, but with that exception the sweet potato is unexcelled for all soils which are not too wet and heavy. They can be planted at any time from May to July, and will be in condition for grazing from the 1st of August until late in November, or during the months when ordinary pastures are dry, and such succulent food is worth more than at any other time. In grazing, the hogs will waste and destroy a large portion of the crop if allowed free range, and the field should be divided so that only a small part of it will be added to the feed lot at any one time.

Peanuts.—Peanuts are very rich in protein, and so are especially valuable for animals which are growing. Their yield in bushels is less than that of sweet potatoes, but their feeding value per bushel is much greater; and, as they are rich in muscle-forming materials while sweet potatoes have their chief value as fat-producers, the two supplement each other. The best variety for grazing is the Spanish, which yields fully as well as others, and its compact growth makes it easier to cultivate. On soils of medium fertility and with ordinary care a yield of from 50 to 75 bushels per acre may reasonably be expected, and as the hogs do the harvesting the expense of making the crop is much less than for securing an equal amount of food from most other crops. Some recent work at the Alabama Experiment Station shows[1] the high feeding value of peanuts in a very striking manner. Six pigs, with a total weight of 184.3 pounds, were used in the test, which lasted six weeks. The peanuts were grown on about one-sixth of an acre, and during the test 373 pounds, or a little more than 6½ bushels of corn, were fed. At the close of the feeding the pigs had more than doubled in weight, having made a gain of 196.4 pounds. Valuing the corn at 40 cents per bushel and the pork at 3 cents per pound, the peanuts, when harvested by the hogs, were worth $18.34 per acre. The expense of cultivating the peanuts was much less than for cultivating an equal area in cotton, and the thin, sandy soil on which the nuts were grown would not have made more than 200 pounds of lint per acre, while the yield of peanuts was 62.6 bushels per acre. In another test at the same station, peanuts alone, peanuts and corn meal, and corn meal alone, were fed to determine their relative pork-producing value. At the close of the sixth week it was found that 2.8 pounds of peanuts alone, or 3.7 pounds of equal weights of peanuts and corn meal had been consumed for each pound of gain, while 10.7 pounds of corn meal alone had been needed to make the same growth. On butchering the hogs used in the tests it was found that the peanuts had greatly softened the pork and lowered the melting point of the lard, and that this was not wholly corrected even when the hogs were fed on corn exclusively for a month before slaughtering. Like other feeds rich in protein, peanuts are more valuable for growing animals than for those intended for immediate killing. The Bulletin says further: "It is highly desirable to arrange a succession of peanut crops rather than to have large areas ripen at the same time, for in wet weather Spanish peanuts will not remain long in the ground after maturity without sprouting."

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[1] Bulletin No. 93, Alabama Experiment Station.

Chufas.—Chufas grow well only on soils which are somewhat sandy, and will make good yields on soils which are too light for any other root crops, and so are specially valuable for soils where the yield of other crops is too small for profit. Like artichokes, they can remain in the ground uninjured through the winter, and so may be used for grazing at any time from November to February. From the fact that the tops of the plants, which are small and grass-like, do not cover the ground sufficiently to prevent the growth of weeds, the crop needs a longer time of cultivation than do sweet potatoes or peanuts, but the yield is large, often from 100 to 150 bushels per acre, and its season for use is so long that the small additional labor required in cultivation is not out of proportion to the value of the crop. At the Louisiana Station[1] they "were a splendid success, suggesting and proving themselves to be a splendid crop for hogs." At the Alabama Station[2] the yield was 172 bushels of green nuts per acre, the amount shrinking to 115.24 bushels when dried. The feeding tests which have been made with chufas show that while seldom profitable as an exclusive feed, they have great value as a fresh and succulent feed for use with corn and other grain.

Cassava.—Cassava is a plant which, from the limited tests it has received, promises to be an extremely valuable forage plant for Florida and for the immediate coast region westward to Texas. The valuable part of the plant is the thickened and starchy roots, which grow from 1 to 3 feet in length and from 2 to 3 inches in diameter. Each plant produces a cluster of these roots, and single clusters weighing from 15 to 20 pounds are not uncommon. Under ordinary field conditions the yield is from 5 to 8 tons per acre, though much heavier yields are often reported. The plants are propagated by cuttings of the stems and branches, which are buried and kept through the winter like sugar cane. Although the plant will survive a mild winter when left in the ground, annual plantings are more profitable. According to analyses made by the Department of Agriculture,[3] the roots contain a much smaller proportion of water than is found in other roots used for feeding, and so are correspondingly richer in food elements which belong principally to the fat-forming group, 89.84 per cent of the dry material being carbonaceous while only 2.59 per cent is protein. Such a food is far more valuable for fattening than for growing animals, but it can be produced at such a low cost that some of the more expensive nitrogenous foods—shorts, peanuts, or cowpeas—can be used with it and so form a good growing ration at a low cost. When hogs have reached nearly their full growth, and it is desired to add fat for finishing off it is claimed that cassava is the cheapest food known. In tests at the Florida Station[1] the increase in weight in hogs fed seventy-five days cost only 1.04 cents per pound from cassava, while the cost of corn-fed meat was 3.06 cents per pound. In this estimate cassava is reckoned at $6 per ton, the price paid for it at the starch factories, though the actual cost of growing it was less than $2 per ton. Similar results have been secured at the Louisiana Station, and for the extreme southern section of the country, where the climate gives at least eight months free from frost, pork can doubtless be produced at less cost from cassava than from any other one plant.

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[1] Bulletin No. 27, Louisiana Experiment Station.

[2] Bulletin No. 16, Alabama Experiment Station.

[3] Bulletin No. 44, Division of Chemistry.

Crimson Clover.—Crimson clover makes good winter grazing along the South Atlantic coast and in some sections of Florida, but has not been generally satisfactory west of Georgia. Occasionally it makes a heavy growth as far west as Louisiana, but has usually been less valuable than the vetch, which matures at the same season. In sections where it grows its grazing value is about equal to that of the vetch; but very few localities have been found where both succeed, though one of the two can be made to grow on nearly all soils, and the one which succeeds best should be grown by every hog raiser for winter and early spring grazing.

Succession and Rotation.—With such a large variety of plants, some of which will furnish grazing at all times, it is not difficult to make a selection for any locality which will give continuous pasturage through the entire year, and which will furnish fully one-half the food for the hog at an almost nominal cost. By arranging a proper rotation much of the ground can be made to produce two crops annually, and as all will be consumed in the field succeeding crops can be grown without the use of fertilizers. The best succession of crops for different soils and localities must vary greatly, and the kinds grown on the hog lots will also be varied by those grown on the other parts of the farm. The size and shape of the lots will be varied by the location of the buildings, the ground available, and the location of the fields. While no one plan can be universally adopted, the following may be used on a great variety of soils and can be easily changed to suit the surroundings:

A field 20 rods in width and 40 rods in length is divided into five sections, each 4 rods in width and containing 1 acre. Shade should be provided by planting mulberry trees along the division fences. Beginning in April, lot No. 1 is planted with sorghum, to be followed by turf oats and vetch in October; No. 2 is planted in sweet potatoes, also to be followed by oats and vetch; No. 3 is planted in peanuts; No. 4 is planted in sweet potatoes in June or July for a late crop; and No. 5 is planted in artichokes. The following year lot No. 1, which was in oats and vetch through the winter, is planted in sweet potatoes, to be followed by oats and vetch in the fall; No. 2, also covered with oats and vetch through the winter, is planted in artichokes; No. 3 is planted in sorghum or Kafir corn, to be followed by oats and vetch in October; No. 4 is planted in peanuts, and No. 5 in sweet potatoes, both to be followed by oats and vetch.

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[1] Bulletin No. 49, Florida Experiment Station.

In the case of some of these crops, as the sorghum and sweet potatoes, it is often better to plant the end nearer the buildings a few weeks before the farther end is planted, so that the entire crop will not mature at the same time. When the lots are planted in this manner, and temporary cross fences are used, so that the hogs have only a few rods of fresh grazing each week, such a 5-acre field will furnish good and constant grazing for from 25 to 50 hogs, together with the pigs which would naturally belong with such a drove. Of course the succession and varieties named may be changed almost indefinitely, and for many localities should be changed. In some sections crimson clover should be substituted for vetch, and on the light, sandy soils in the extreme southern section cavassa should take the place of artichokes. Chufas will sometimes be better than artichokes, and, when the hogs are to have fall grazing in a cornfield which has been planted with cowpeas, the peanuts may be omitted and some other crop increased. In arranging any such rotation the important point is to select crops which will give an uninterrupted succession, and the most abundant grazing at times when but little is to be had from other parts of the farm. It should be remembered that the meat which the hogs make by grazing is the least expensive, and it is poor economy not to make as much of it as is possible.

GRAIN AND OTHER FEEDS.

A certain amount of grain feed is needed to grow hogs with the greatest profit, and still more is needed to fatten and fit them for market, but it should be used only to supplement the feeds which the hogs harvest for themselves in the field. Pork can not be made economically when all, or even a larger proportion, of the feed comes from the crib or the mill. The hog is an omnivorous animal and needs "roughage" and fresh green feed for his best health and growth and to produce meat of the best quality. When young his grain feed should be such as will furnish material for bone and muscle, and not such as will produce an excess of fat; while, as the animal approaches maturity, fat-producing foods should be given more liberally. No one kind of grain feed can be used economically from weaning until the full-grown animal is slaughtered, and there should be a gradual change from the nitrogenous, muscle-making food given to the pig to the carbonaceous, fat-making food, which is more profitable for the last few weeks before killing. The young animal must have good bone and muscle before it can carry the heavy load of fat desirable for the butcher or develop the strength, vigor, and health necessary in a good breeding animal.

Corn.—Corn has always been the staple grain food for hogs and is the best and cheapest for "finishing off" to make the animals ready for butchering. It makes the meat very firm, gives it a fine flavor, and makes a better lard than can be obtained from any other food. It is strictly a fattening food, however, and is not the best grain for young animals or for breeding stock. When young animals have an abundant range with a good supply of nitrogenous foods like alfalfa, clover, vetches, and cowpeas, corn makes a valuable addition to the ration, but should not be given in excess, and will usually be found more profitable if mixed with shorts, bran, or some other feed containing a larger proportion of protein. For the last few weeks before slaughtering, corn alone is often the most economical grain food. Little advantage will be secured by grinding it before feeding. Numerous tests have been made, by the experiment stations and by other feeders, in comparing whole corn with corn meal, and although the results have usually been in favor of the meal by from 4 to 8 per cent, that difference will barely pay the cost of grinding. Corn meal or soaked corn can sometimes be used to advantage in feeding young pigs, but under ordinary circumstances it is fully as profitable to feed the corn dry and whole.

Shorts and Bran.—Shorts and bran are among the best feeds for growing animals, and when they can be had for $20 or less per ton will always be more profitable than corn for young stock. For young pigs bran is not so good as shorts, as it often has an irritating effect on the bowels, and when fed too liberally causes scours and other troubles from which the animal is slow in recovering. Shorts, when fed in reasonable amounts, seldom causes such troubles and is usually the best and cheapest grain feed for use during the first three or four months. As the animal grows older bran may be used more freely.

Cowpeas may be used in the place of shorts or bran, but as they require grinding their economical use is confined to the feeding of young animals, and the crop can commonly be used more profitably in other ways.

Rice bran and rice polish are cheap grain foods in the rice districts, but their feeding value is not equal to that of corn meal. They consist almost wholly of starch, and so are better for fattening than for growing stock.

Cotton Seed.—Cotton seed has been used in almost every form for feeding hogs, but never with success when the feeding has been continued any length of time. It has been fed raw, roasted, steamed and boiled; and the meal, both raw and cooked, has also been tried in various ways, but almost always with the same result—the death of from one-fourth to one-half the drove within twelve weeks from the time the feeding began. Apparently the hogs do well the first few weeks after the feeding begins, but at about the sixth week occasional deaths occur, and the losses continue from that time onward. The hogs show no indication of sickness and make very satisfactory gains until within two or three days or sometimes within a few hours of death, and no curative treatment seems to have any effect. Nearly every experiment station in the Southern States has endeavored to find some combination of feeds, of which cotton seed should be a part, which could be fed with safety, but without success, and it seems useless to make any further attempt to use it as a hog feed. Before it had any commercial value cotton seed was often thrown into shallow ponds, where it soon became half rotted, and, when in that condition, hogs often ate it with impunity, but with the present market value of the seed more than double the amount of food can be secured by exchanging it for corn or shorts.

Skim Milk.—Skim milk should always be used when it is available. It is not only a good flesh producer in itself, but it also makes the ordinary grain feeds more digestible and so adds greatly to their value. While skim milk alone is rarely profitable, from 20 to 40 pounds being required to make a pound of meat, when mixed with grain in the proportion of 3 pounds or less of milk to each pound of grain its value is greatly increased. In a test reported by C. P. Goodrich[1] 1 bushel of corn produced 10 pounds of pork, and 100 pounds of skim milk produced 5 pounds of pork, when fed separately. When fed together, however, the mixture produced 18 pounds of meat, an increase of 3 pounds due to the mixing. In this case 100 pounds of skim milk took the place of 44.8 pounds of corn. If the corn was worth 25 cents per bushel, the milk was worth 19.6 cents per 100 pounds; if the corn was worth 40 cents, the milk was worth 31.4 cents. Extended tests in the feeding of skim milk have been made at the Utah Station,[2] and among the facts brought out by the work are these: "The hogs fed on the milk-and-grain ration made much more rapid gains than either those fed on milk alone or on grain alone. The time required to make 100 pounds of gain was seventy-nine days for the hogs fed on milk and grain, one hundred and sixteen days for those fed on grain alone, and one hundred and forty-seven days when the feed was milk alone. The milk-and-grain-fed lots required 2.58 pounds of digestible matter, the milk-fed lots 2.85 pounds, and the grain-fed lots 3.19 pounds to make 1 pound of gain in live weight." In this case 100 pounds of skim milk took the place of 23.2 pounds of grain in the mixture. Work at other stations has given very similar results and has demonstrated that when not more than 4 pounds of skim milk is used with each pound of grain the milk is worth from 15 to 30 cents per 100 pounds. The younger and smaller the hogs the higher is the value of the milk. For full-grown and aged animals it is of less value. It may be taken as a safe rule that it is profitable to pay at least 15 cents per 100 pounds for all the skim milk needed to make four times the weight of the grain fed, and where it is impossible to secure enough for all the hogs the available supply should be given to those pigs nearest the weaning age and to sows suckling pigs.

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[1] Pork production, p. 91.

[2] Bulletin 57, Utah Experiment Station.

Salt and Ashes.—One item of feed which should never be neglected is a good supply of salt and ashes to which the hogs can have access at all times. Wood ashes can always be had and the hogs should have all they will eat. When not convenient to give ashes, charcoal is a good substitute, and even soft coal will be eaten for want of something better. Hogs are never injured by eating all the ashes they want, but it is not safe to give large amounts of salt to animals not accustomed to its use. The salt and ashes mixture should be kept in a low box under a shed where it will be protected from rain, and should consist of about two quarts of salt for each bushel of ashes. Many feeders prefer to add a few ounces of copperas to the mixture. Free access to such a mixture will do much to preserve the health of hogs, and sows which have had an abundance of such food will rarely eat their young.

Cooking the Feed.—Cooking feed is rarely profitable. It has been tested repeatedly in all parts of the country and with all kinds of feed, often with contradictory results, but those who have tested it most extensively and who have watched its results most carefully are almost unanimous in the opinion that cooking not only fails to increase the meat-producing value of the feed, but often actually causes a distinct loss. Irish potatoes are greatly improved by cooking, but as they are seldom fed to hogs in the South the purchase of a cooking outfit is usually a needless expense for the southern hog raiser. Soaking grain in water and allowing it to ferment before feeding is also seldom profitable, though soaking corn or wheat for very young pigs enables them to begin eating a little sooner. When ground feed—shorts, meal, etc.—is used with skim milk many feeders think it better to make them into a slop and let it stand until it begins to ferment, but the mixture should never be kept until it becomes soured.

HOW AND WHAT TO FEED.

Whatever feeds may be used the variety should be as great as possible, and changes should be made at every opportunity. The only object in raising hogs is the production of meat, and the more rapidly a hog can be made to produce meat the more profitable he becomes. The man who makes hog raising the most profitable is the one who induces his hogs to eat the most of the right kinds of food, and who never keeps them on any one kind of grain or forage until their appetites become cloyed and they get "off their feed." The greater the variety and the more frequent the changes the more will be eaten and the more rapid will be the growth.

No matter what food may be used or what the age of the animals which consume it a great saving may be effected by feeding so that none of it will be wasted. While a hog is not over particular about cleanliness, and will eat food which is covered with almost any kind of filth, still he prefers clean food, and will not waste time and strength in rooting half an ear of corn out of the mud when he sees an ear which has not been soiled. Throwing corn, or any other feed, on the ground is wasteful, and if, as is too often the case, the hogs are kept in a small pen which is trampled and rooted so that it has become a permanent mud hole, the practice is exceedingly wasteful. In managing the grazing lots, especially those on which root crops are grown, the temporary cross fences, already referred to, will save from one-fourth to one-half the feed. It pays, and pays well, to have a floor on which to feed corn; and when shorts or other ground feeds are used they should always be wet and fed in a trough. The trough should have end pieces so long that the hogs can not turn it over, but should not be fastened to the floor, as it will need cleaning often. The feeding floor and trough should be under a shelter if possible. It is never a good plan to feed animals of different sizes in the same pen. When large and small are fed together the small are sure to suffer, no matter how much may be given to the lot. The food which an animal gets by fighting may sustain life, but it will make very little fat. An ample variety of feeds suited to the age of the animals, and a feeding place where none of it will be wasted are the two important factors in profitable hog raising. In regard to feeding hogs, Hon. W. L. Foster, of Shreveport, La., who has been for many years one of the largest breeders in that State, says:

> On the hill lands, rye, barley, oats, and artichokes are the best for winter grazing, taking the hogs off the grain crops about the last of February to permit the crops to mature seed. Sorghum, to come in shortly after barley or rye, ought to be planted in Spanish peanuts, sweet potatoes, and peas. Turn the hogs onto the oats when the seed is about ripe; then on the peas, sweet potatoes, and peanuts when sufficiently matured; then on artichokes again for the winter. Of course Bermuda pasture for summer grazing is a *sine qua non*. On alluvial lands I would say alfalfa for pasture the year around, with straight corn, hard (or better if soaked twenty-four hours). The alfalfa should be cut and fed when the ground is too wet to pasture. Hogs should run out at all times, but should have Λ-shaped shelters to go under when very cold or extremely hot.
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> For grain feed I think corn alone, and not much of it, good enough with alfalfa or clover. Skim milk with shorts, bran, oats, and corn meal in equal parts is, to my mind, the *best* feed, but hardly profitable for hogs intended for slaughter. I do not think it pays to cook feed, other than turnips, Irish potatoes, or similar crops, which are made more palatable. For growing pigs on alfalfa, soaked corn is good enough; while for pigs on Bermuda grass I think shorts, oats, and corn almost necessary to good results, unless one has plenty of peas, sorghum, and vegetables, or milk. For fattening I prefer the same feeds as for growing except to increase the proportion of corn.

In writing of the same matter, Professor Duggar, of the Alabama Experiment Station, says:

> On sandy soils a suitable succession of crops for hogs is a mixture of hairy vetch and oats for spring grazing; permanent pastures, especially lespedeza, carpet grass, and Bermuda for June and part of July; sorghum or permanent pasture for July and a part of August; peanuts for August and September and October; sweet pota-

toes and the run of cowpea fields for November, and chufas for November, December, and January. The peanut diet, the cheapest of all the methods of growing pork yet tested here, should be discontinued at least two months before the hogs are killed. Corn should be the chief food in the few weeks immediately preceding slaughtering. Some corn must be fed to hogs on pasture, and can be fed profitably even when pigs are running in peanut fields. As soon as we have large enough areas of alfalfa we shall have a still cheaper method of growing pork. If pigs must be grown chiefly on grain, I prefer either a mixture of two parts corn and one part of cowpeas ground together, or shorts. Bran is too coarse. We have found sweet potatoes to be not more than one-fourth as valuable as an equal weight of corn, and yet when harvested by the hogs, sweet potatoes constitute a valuable food on poor, sandy soil.

Director Redding of the Georgia Experiment Station uses nearly the same feeds. He says:

> The best succession of grazing crops is vetches (*Vicia sativa* and *V. villosa*), clovers (*Medicago maculata* and *M. denticulata*), red clover and orchard grass, crab grass, chufas, peanuts, sweet potatoes, and artichokes. For permanent pastures Bermuda grass is best for summer, while orchard grass, tall oat grass, red top, red and white clovers are best for winter and spring.
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> For feeds for the growing period I use shorts, bran, corn meal, and pasture; for the fattening period, peanuts, sweet potatoes, artichokes, and corn meal. Skim milk is undoubtedly good for growing pigs; bran and oats are unexcelled excepting by shorts.

FATTENING FOR MARKET.

The cost per pound of growing and fattening a hog for market increases with the size and age of the animal. It costs much less to raise two hogs weighing 300 pounds each than to grow one weighing 600 pounds, and even 500 pounds is too heavy to be profitable under ordinary circumstances. A hog must consume a certain amount of food to maintain his present weight, and for that food the owner receives no returns. Whatever the hog can be induced to eat in excess of the amount required for maintenance goes to the production of growth, and it is from this excess that all gains and profits are made.

These facts make it to the interest of the feeder to induce his hogs to eat all they can digest and to secure gains as rapidly as possible. A pig which is made to weigh 200 pounds at six months or 300 pounds at a year old is always profitable, while if it takes two years to make 300 pounds the last 100 pounds will usually be made at a loss. As the rate of growth, both in proportion to the size of the animal and to the amount of food given, decreases as the hog becomes larger, there must come a time when a pound of increase will cost more than it will bring on the market, and it is a nice point with the feeder to decide when that time will come and to market his hogs before it is reached. Ordinarily, this time will come when the hog weighs from 250 to 300 pounds, but may be reached either above or below those weights.

A hog 1 year old and weighing 300 pounds in November may still make a profitable gain if he has the gleaning of a recently harvested cornfield with an abundance of cowpeas, the leavings of a sweet potato field, or any similar food which would otherwise be wasted, but if none of these feeds are available, and all the food consumed must be purchased, it will be more profitable to sell at once, even if the weight is not more than 200 pounds.

As showing the increased cost per pound of gain with the increase in weight, Professor Henry, of the Wisconsin Station, has compiled[1] the results of more than 500 tests made at many different experiment stations. More than 2,200 hogs were used in these tests, and the work has been so extensive and carried on through so many years that the results may be regarded as very conclusive evidence. The figures are as follows:

Weight of pigs.	Average feed per day.	Feed eaten daily per 100 pounds of live weight.	Average gain per day.	Feed eaten for each 100 pounds of gain.
Pounds.	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*
15-50	0.223	5.95	0.76	293
50-100	3.35	4.32	.83	400
100-150	4.79	3.75	1.10	437
150-200	5.91	3.43	1.24	482
200-250	6.57	2.91	1.33	498
250-300	7.40	2.74	1.46	511
300-350	7.50	2.35	1.40	535

From these figures it is seen very plainly that the greatest as well as the most profitable gains are made on the lighter hogs, the last column showing a constant and almost regular increase in the amount of feed consumed for each 100 pounds of gain. Up to the time when the pigs weighed from 200 to 250 pounds each it required an average of 422 pounds of feed for each 100 pounds of gain, while for those exceeding 250 pounds in weight 523 pounds, or nearly 24 per cent more food was required to produce an equal gain. Pigs weighing less than 100 pounds each made the greatest gains for the food consumed, needing only 347 pounds of feed for each 100 pounds of gain, and, if feed were the only consideration, the 100-pound pig would be the most profitable; but there are other expenses which must be charged against him. The cost and care of the boar and sow are the same whether the pigs are butchered at 100 or 500 pounds. Losses are much more frequent among young pigs than among those which weigh more than 100 pounds each, and, while there is a limited demand for "pig pork" at good prices, such pork can not be sold in unlimited quantities, as packers want only hogs which are fairly well matured. These expenses, risks, and market conditions all combine to make a somewhat heavier animal more profitable, even at some additional expense for feed. Although the figures given above represent the actual amounts of food consumed by pigs of different weights, they do not represent exactly the cost of the feed. The food of the younger pigs must consist largely of the more costly feeds, shorts, oats, pease, etc., while the older animals can be kept in good condition on coarser and cheaper foods, such as sweet potatoes, sorghum, or artichokes. When steers are being fattened on whole corn, hogs running in the same feed lot will secure a large proportion of their feed without expense from the droppings of the cattle. This will not be the case, however, when the steers are fattened on other feeds, corn meal giving very little feed for the hogs, and droppings from the steers fed on cotton-seed meal, the common fattening feed in the South, often prove positively injurious.

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[1] Henry—Feeds and Feeding, p. 551.

So long as a pig is making a fair gain on feed of which he gets at least one-half by grazing it is usually profitable to keep him, but after he reaches salable maturity, is in marketable condition, and draws a large proportion of his feed from the crib, he should be sold at once.

Usually it is better to have hogs ready for market as early as November or December, and it rarely pays to feed through the winter for making pork. Summer feeding is cheap while winter feeding is expensive. Pigs farrowed in the spring should weigh from 200 to 250 pounds by fall, and if the market is not unusually depressed it is better to let them go then rather than to feed through the cold weather and risk still lower prices in the spring. If good grazing is assured through the entire winter and grain is not too expensive, winter feeding is sometimes profitable on account of the higher prices which usually prevail in the spring, but ordinarily it is better to winter only the breeding animals and the fall pigs.

For the last few weeks of fattening, corn is undoubtedly the best grain feed, as it produces a meat which is of good flavor, prime, and wholesome. Hogs can be fattened cheaply on many other feeds, but the meat is greatly modified by the feed consumed during the last six or eight weeks, and animals which have been fattened on peanuts, cowpeas, mast, and similar foods should have corn as their finishing feed. Peanuts especially have a very softening effect on the lard, as is shown by Duggar,[1] who found the melting point of lard from corn-fed pigs to be 111.2° F., while that from peanut-fed pigs is only 76.1° F.

Feeding for the finish should not begin more than ten or twelve weeks before the hogs are to be sold. Hogs which have had good grazing through the summer and enough grain feed to keep them growing well take on flesh rapidly during the first few weeks of heavy feeding, but the longer the feeding is continued the slower and more expensive will be the gains. In testing this matter at the Wisconsin Station,[2] where pigs were fed twelve weeks, the average weekly gains during the first four weeks were 11.5 pounds each; during the second four weeks, 11.5 pounds; and during the third four weeks, 9.5 pounds. Although the actual gains during the second four weeks were equal to those of the first four, the increase was made at a much greater cost of food, the amount of feed required for each 100 pounds of growth during the first month being 418 pounds, during the second month 461 pounds, and during the third month 559 pounds, or one-third more than was required during the first month. Quick work pays in fattening as well as in growing hogs, and when the animals are on good feed and fail to make a gain of at least 1 pound daily they should be sold or butchered.

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[1] Bulletin 93, Alabama Experiment Station.

[2] Report Wisconsin Experiment Station, 1897.

The man who is raising hogs in such numbers that he can ship them by the carload should time the farrowing and the final breeding so that he can fill a car with animals of nearly the same ages and weights, as such lots always bring much better prices than do mixed lots containing animals of different sizes and uneven in maturity. The man who raises only a small drove will usually find a demand for them in his local market, and where such a demand exists he will find it profitable to have a few animals in condition for butchering at any time except during the hot summer months.

DISEASES AND INSECTS.

The diseases affecting hogs in the South are very few, but are somewhat difficult to recognize, and still more difficult to treat successfully. Practically, the only contagious diseases which cause serious trouble are cholera and swine plague, which, though different diseases, resemble each other very closely and require the same treatment. Both are highly infectious and cause the loss of a large proportion of the animals attacked.

HOG CHOLERA AND SWINE PLAGUE.

Dr. D. E. Salmon, Chief of the Bureau of Animal Industry, gives the symptoms of these diseases, as follows:

> There are first seen the signs of fever, shivering, unwillingness to move, more or less loss of appetite, and elevation of temperature, which may reach 106° to 107° F.; the animals appear stupid and dull, and have a tendency to hide in the litter or bedding and remain covered by it. The bowels may be normal or constipated at the beginning of the attack, but later there is generally a liquid and fetid diarrhea, abundant, exhausting, and persisting to the end. The eyes are at first congested and watery, but soon the secretion thickens, becomes yellowish, accumulates in the angles, and gums the lids together. The breathing is more rapid than usual, and may be oppressed and labored in the later stages. There is a cough which, however, is not very frequent, and generally heard when the animals are driven from their beds. It may be a single dry cough, or it may be paroxysmal. The skin is often congested and red over the abdomen, inner surface of the limbs, under surface of the neck, and on the ears. The color varies from a pinkish red to dark red or purple. An eruption is sometimes seen, which leaves crusts or scabs of various sizes over the skin. There is a rapid loss of flesh, the animal grows weak, stands with arched back, and abdomen drawn up, and walks with a tottering, uncertain gait. There is less and less inclination or ability to move, and the weakness and exhaustion increase until death results.

The symptoms of swine plague in many cases are not noticeably different from those of hog cholera. Frequently, however, the lungs are—

> extensively inflated in swine plague, and in that condition the breathing is more oppressed and labored, and the cough more frequent and painful.
>
> The course of these diseases varies from one or two days to two or three weeks.

Although there is no known remedy which is invariably successful, Dr. Salmon recommends the use of the following:

	Pounds.
Wood charcoal	1
Sulphur	1
Sodium chloride	2
Sodium bicarbonate	2
Sodium hyposulphite	2
Sodium sulphate	1
Antimony sulphide (black antimony)	1

These ingredients should be completely pulverized and thoroughly mixed.

The dose of this mixture is a large tablespoonful for each 200 pounds weight of hogs to be treated, and it should be given only once a day.

He also says:

> Hogs are fond of this mixture; it increases their appetite, and when they once taste of food with which it has been mixed they will eat it though nothing else would tempt them.
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> Animals that are very sick and that will not come to the feed should be drenched with the medicine shaken up with water. Great care should be exercised in drenching hogs or they will be suffocated. Do not turn the hog on its back to drench it, but pull the cheek away from the teeth so as to form a pouch into which the medicine may be slowly poured. It will flow from the cheek into the mouth, and when the hog finds out what it is it will stop squealing and swallow. A very easy method is to cut off the toe of an old shoe, insert the cut end into the hog's mouth, and pour the medicine into the shoe. In many of our experiments hogs which were so sick that they would eat nothing have commenced to eat very soon after getting a dose of the remedy, and have steadily improved until they appeared perfectly well. This is particularly the case when the disease is hog cholera.
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> This medicine may also be used as a preventive of these diseases, and for this purpose should be put in the feed of the whole herd. Care should, of course, be observed to see that each animal receives his proper share.

With these, as with all other diseases, prevention is much better than treatment. If cholera is known to be in the neighborhood the hogs should be confined in a small lot in which there is no stagnant water and where they will be protected from excessive heat or cold. They should be fed well, principally with bran, shorts, and other soft feeds, in which should be mixed a daily dose of the mixture described above. No one who has recently visited a place where the disease exists should be allowed to go near the lot. Care should be taken that the hogs have no access to any ground which receives drainage from an infected locality. Any animals which are purchased should be quarantined at least a month before being put with the drove.

Should the disease make its appearance in a drove, all the animals which appear to be still unaffected should at once be separated from the sick and placed in a pen as far away as possible. Should the disease appear among those which have been moved, the sound animals should be moved to still another place. It is of little use to move the sick, as the lot in which they have been kept is thoroughly infected. Different feeders should care for the sick and the well for fear of carrying the contagion, as a bit of manure no larger than a pin head might easily be carried on the foot from the sick to the pen where the healthy animals are kept, and so spread the disease.

The carcasses of any animals which die from the disease should be burned immediately. Burying them is not safe, as the germs of the disease may retain their vitality for months when in damp soil, and if brought to the surface by dogs or worms, may cause another outbreak of the disease at any time. The lots where sick animals have been kept should be thoroughly disinfected by sprinkling heavily with lime, and should not be used again for at least six weeks. The disease is so fatal and so difficult to treat successfully that too much care can not be taken to prevent its introduction or spread.

THE HOG LOUSE.

The hog louse is the only insect which causes much trouble in raising hogs, and when it once becomes established in a drove it is not easily exterminated. Fortunately the lice are so large that they can be seen easily, and their presence may therefore be known before they become very abundant. They are liable to appear at any season of the year, and they thrive on hogs of any age or condition. They are found in and behind the ears, back of the shoulders, and in the creases on the lower part of the ham more frequently than elsewhere; if those places are free from them there is little danger that they exist on other parts of the animal. Coal oil is sure death to every louse it touches, but does not always kill the eggs, and must be used with caution to prevent its blistering the skin of the hog. When a large drove is to be treated, the work can be done very quickly by using a spray pump having an attachment for mixing the oil and water, and the pump should be set so that it will use about five parts of water to one part of oil. When such a mixture is thrown over the hogs in a fine spray, only a little of the oil is used to cover the whole animal, and if the spraying is done in the evening, nearly all of the oil will have evaporated by morning and there will be no blistering of the skin when the hogs are exposed to the hot sun on the following day. So little oil is used in the spraying that few of the eggs will be killed, and the work should be repeated at the end of a week, and again at the end of the second week. If the work is thoroughly done, three sprayings will be sufficient. If a spray pump is not available, the hogs should be rubbed with a mixture containing two parts of lard oil to one of coal oil, repeating twice at intervals of a week. The sleeping places should be thoroughly cleaned, the bedding burned, and the inside of the buildings thoroughly wet with coal oil.

Even with the most thorough treatment it requires time and patience to clean a drove which has become badly infested, but it must be done if the hogs are to be kept in a thriving condition. It is not difficult to destroy the larger part of the lice, but that is not sufficient, for where there are even a few eggs left in the ears or under the jowls of a single animal the pest will soon become as bad as ever.

Lice never infest clean hogs when they are not brought from an infested drove, and the hog raiser who has a clean herd can not be too careful to keep it so. No stray hog should be allowed on the premises, and any which are purchased should be examined very carefully before they are allowed to run with the others. The oil mixture should always be kept close at hand where it can be used immediately if any indications of lice are seen. It is much easier to kill a few lice on a few animals than to clean a thoroughly infested herd.

STATEMENTS OF SUCCESSFUL HOG RAISERS.

The following quotations give some of the actual practices followed by successful hog raisers and suggest some of the most serious obstacles likely to be encountered.

In speaking of raising hogs for pork, Mr. Foster, of Louisiana, to whom reference has already been made, says:

> I think two litters should be raised where winter pasture can be had cheaply; otherwise only a spring litter to be turned off at eight or nine months. In feeding breeding sows I simply see that they are improving in flesh and strength and have laxative food before farrowing. If pasture does not keep their bowels in good condition, I feed bran or cotton-seed meal for a short time previous to farrowing. On our plantation I put up 32,000 pounds of green bacon last winter at a cost of a little less than 3 cents per pound on corn and alfalfa pasture, charging corn at 40 cents per bushel and pasture at $5 per acre, but charging nothing for fencing, shelters, or labor, as the pasture (40 acres) furnished a great deal of feed for my colts, mules, and cows. The greatest obstacle to success, I think, is disease caused in a majority of cases by crowding too many hogs together and disregarding sanitation. I never keep more than three or four litters, having my pasture subdivided by portable fences into small lots of one-half to 1 acre each, with a cheap shelter in each lot. I never saw all of a large bunch of hogs do well when fed together. The fewer in a drove the better.

Professor Duggar, of Alabama:

> Two litters a year are practicable and profitable.
>
> The principal obstacles to success are:
>
> (*a*) The want of a market at steady prices. We need packing houses.
>
> (*b*) The attempt to make corn, which is high-priced in most Southern communities, the main or sole food for the hog. We need special hog crops, and pastures prepared especially for hogs.
>
> (*c*) Cholera, which is largely preventable by proper fencing, feeding, and a knowledge of the means by which it is disseminated.
>
> (*d*) The cost of making hog-tight fences around fields where hog crops should be grown.
>
> (*e*) Scrub blood.
>
> (*f*) Financial loss due to keeping hogs past the age of twelve or fifteen months, and similar errors of judgment due to want of information.

Dr. Redding, of Georgia, says:

> I prefer to have sows farrow in March, the pigs to be made into bacon the following December; farrow again in September, the pigs to be sold for butchers' meat and consumed fresh. The March pigs in December should net 200 to 225 pounds each. The salted pork should be ready for "smoking" by February 1. The September pigs should be kept in good butchers' condition and sold as the market may demand.
>
> Before farrowing, sows should be kept in good, thrifty condition, but certainly not fat, with moderate exercise required, or at least provided for. After farrowing, the

best and most nutritious and milk-producing food should be given—mashed and scalded oats, shorts, bran, corn meal wet up with water, some green food, and pasture. Plenty of pure, clean water is desirable. The little pigs should be taught to drink skim milk, thin bran mashes, and the like as soon as possible. Later they should have a regular allowance of mashed oats, bran, and corn meal, with such green food as may be available. I consider the common collard an excellent soiling food for hogs. The collard leaves are especially suited for growing stock of all kinds, but particularly for hogs. The plants should be set out 1 foot apart, in 3-foot rows, in rich soil, in April. In a few weeks feeding may begin by pulling out every third plant and feeding them whole. Later, each alternate plant of those remaining may be removed and fed. After the patch has been thus thinned to one plant every 3 feet, commence to "prime;" that is, pluck off one or more of the bottom leaves of each plant, and so on all summer and fall.

Lucerne is an excellent soiling plant, better and more convenient than red clover. The saccharine sorghums, and Indian corn (in roasting ear) fed "stalk and all," are both good.

It should not cost over $5 or $6 to produce a hog weighing 200 pounds.

I know of no insurmountable obstacle to profitable hog raising throughout the South. In fact, there is hardly an impediment in the way. Want of well-established pastures is noticeable.

CONCLUSIONS.

The obstacles mentioned can readily be overcome. Diseases caused by overcrowding can be avoided by building a few fences and cheap shelters. The exclusive or excessive use of corn is wholly unnecessary in view of the many other feeding crops available; and it is not economical by reason of the smaller cost of other feeds which are equally good or better for use, except during the short time of fattening. Scrub blood is as unprofitable in Kansas or Ohio as in Texas or Florida; pure-bloods can be obtained in one place as readily as in another, and with the use of well-bred stock every animal can be made ready for market without keeping it beyond twelve or fifteen months. Packing houses will be built as soon as the supply of hogs is in excess of the local demand, and until then the farmer will find it profitable to be his own packer. The man with a small herd will make a much better profit in proportion to his investment than the man who grows for shipment. With such a favorable climate, and with food crops which can be produced at so little cost, hog raising can be made profitable on every farm in the South.

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